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Note on Train Speeds,

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PART II. *(Continued.)* [1]

Train speeds and services in different countries.

II. — FRANCE.

CHAPTER XIII.

The railway system.

XIII-1. — **Generalities.** — As France is a highly centralised country, its railway system shows the same characteristic, so that nearly all the important lines radiate from Paris towards the large provincial towns and the neighbouring countries. When going from one provincial town to another, it is frequently faster and more comfortable to go via Paris, even if this makes the route longer.

The reason for this is that the country is divided up into sectors with Paris as the peak, and each sector is served by a railway company or by the State Railways. Only two railways are an exception to this rule : the *Midi* which has just made a close working agreement with the *Paris-Orleans* Company, and the *Alsace-Lorraine* Railways which used to be part of the *Est* Railway whose boundaries have recently been altered by an exchange of sections of line, so that this railway now runs to Belfort and the *Est* runs to Metz.

Nevertheless efforts have been made in recent years to establish certain direct inter-provincial connections, particularly from centres at a distance from Paris, such as Strasbourg, Bordeaux and Lyons, and though there is hardly any competition between the different French railways, these services are remarkable for

(1) See *Bulletin of the International Railway Congress Association*, October 1933, page 885; November 1933, page 1027, and January 1934, page 63.

Fig. 32. — Cartogram of French train speeds.
(See legend, fig. 7, page 1028/46 of the November, 1933 *Bulletin.*)
All places having non-stop runs from Paris are underlined.

the speed of all their trains, and their overall speed, which is higher than anywhere else. Against this, the number of express trains between given towns is smaller than in other countries, such as England.

Finally in most continental countries, the greater number of the « de luxe » trains, sleeping cars and restaurant cars belong to the International Sleeping Car Company, which operates them. Consequently we must consider at the end of this article the French services of this Company and we will carry out our investigations in the following order :

CHAPTER XIII. — THE RAILWAY SYSTEM.

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3. Competing lines.
4. Alternative routes.
5. Cross-country, boundary, and inter-company lines.
6. « Forks ».
7. Seaside and other resorts.

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3. Boat trains.
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CHAPTER XV. — SLEEPING-CAR, SALOON-CAR, AND DINING-CAR SERVICES.

1. The Companies' sleeping-car services.
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3. The French services of the International Sleeping Car Company.
4. Trans-Capital services.

CHAPTER XVI. — SPEEDS.

1. Generalities.
2. High-speed lines.
3. Fast runs.
4. Long non-stop runs.
5. Conclusions.

The train times, as well as the distances, are taken from the « Indicateur Chaix » of the 15th May 1933, for the Summer season.

XIII-2. — **The radiating lines.** — The main line companies have express services over thirteen lines radiating from Paris, most of which divide up again, and are distributed as follows (cf. table 81) :

The three main lines of the *Nord* Railway radiating from Paris divide up into nine, four of which are served by fast expresses. As a rule there are no steep gradients, and the Company has systematically eliminated everything that would give rise to service slacks, which policy enables it to run at overall speeds higher than those of any other railway in the World. As a result only one swingbridge is left, at Abbeville on the Somme, which is run over at a speed of 100 km. (62 miles) an hour (1).

The *Est* Railway system has striking analogies with the *Nord*, although the war of 1870 cut off the ends of its radiating lines, which since then have formed part of the *Alsace-Lorraine* Railways, but the other characteristics of the railway have not changed.

This situation occupied the minds of those in authority and, by modifying the agreements of 1921, they were able to remedy in some way the difficulties caused by the arbitrary partition made between the two Systems, which neither of them respected — the locomotives of each system often going a long way on the other's lines — by exchanging some of the sec-

(1) There are, in fact, two others, one at Gravelines, on the Aa (line from Calais to Dunkirk) and the other at Aire-sur-la-Lys (line from Berguette to Saint-Omer). But these are secondary lines where the speed is necessarily lower.

TABLE 81.

MAIN LINES RADIATING FROM PARIS.

(See fig. 32.)

Company.	LINE FROM PARIS TO	Distance.		Further place of destination.	Distance.	
		Km.	Miles.		Km.	Miles.
Nord.	Beauvais-Le Tréport.	183	113.8	Mouscron	276	171.5
	Creil-Amiens-Calais	299	185.8	Brussels	311	193.2
	Do. do. -Lille	258	160.3	Liége	367	228.1
	Do. Aulnoye-Feignies	231	143.5			
	Do. do. -Jeumont.	238	147.9			
	Laon-Hirson	197	122.6			
Est.	Meaux-Mézières-Longuyon-Longwy. .	347	215.7	Luxembourg. . .	377	234.3
	Do. do. do. -Audun . .	356	221.2	Metz.	411	255.4
	Do. -Châlons/M.-Amanvill.-Metz .	335	208.2			
	Do. do. do. -Nancy-Avric.	412	256.0	Strasbourg . . .	503	312.6
	Chaumont-Belfort.	443	275.3	Basle	526	326.8
	Do. do. -Delle	465	288.9	Bern.	590	366.7
P.-L.-M.	Dijon-Besançon-Belfort.	503	312.6			
	Do. do. -Pontarlier	455	281.5	Neuchâtel	508	315.7
	Do. do. -Vallorbe	463	287.7	Lausanne	510	316.9
	Do. -Bourg-Geneva	604	375.3			
	Do. -Modane	673	418.2	Turin	779	484.1
	Do. -Marseilles-Ventimiglia . . .	1123	697.8	Genoa	1274	791.0
	Nevers-St. Germain-Lyons.	508	315.7			
	Do. do. -Nîmes	724	449.9			
P.-O.	Orleans-Vierzon-Aurillac	559	347.4			
	Do. do. -Montauban . . .	666	413.8	Port-Bou	974	605.1
	Do. -Bordeaux-St-Jean	588	365.4	Hendaye.	820	509.5
	Do. -Tours-Le Croisic	524	325.6	Quimper.	685	425.6
State.	Chartres-Thouars-Bordeaux	615	382.1			
	Do. do. -La Rochelle. . .	...	...			
	Do. -Le Mans-Brest	624	387.8			
	Argentan-Granville	328	203.8			
	Mantes-Cherbourg	371	230.5			
	Do. -Havre.	228	141.7			
	Dieppe	169	105.0			

tions of lines so as to enable the *Est* Railway to run to Metz and the *Alsace-Lorraine* to reach Belfort.

The position of the *Midi* Railway in connection with the *Paris-Orleans* Railway was similar to that of the two railways we have just mentioned; in this case, however, the Companies themselves came to a more complete agreement than that between the other two railways. They did not want to amalgamate altogether, as this would require special legislation and take a long time, and they consequently drew up a working agreement which groups them under the same authority.

This was all the more important as the main line of the *Midi* Railway, which

runs from Bordeaux to Sète, is really only a cross-country line, whereas all the radiating lines from Paris cross this railway system before they reach the frontier. Starting from Paris, these include two main lines which soon divide up into four international lines. The two outer lines avoid the Pyrenees : the western line is the Bordeaux line which continues to Hendaye-Irun, and the eastern is the Paris-Vierzon-Port Bou-Barcelona lines. The two central lines cross the mountains. For this purpose, the Paris-Vierzon-Limoges line branches off to Agen, from where there is an extension to Pau, Canfranc and Saragossa on the one hand, and to Toulouse, Puigcerda and Barcelona on the other.

Although the *Paris-Lyons-Mediterranean* (P.L.M.) Railway is the largest of the French Systems (9 914 km., *i.e.* 6 160 miles in 1932), at its departure from Paris it has only two main lines. At Dijon the principal line divides up into six directions, five of which go towards the eastern frontier, where they run through the Jura and the Alps through long tunnels (1).

XIII-3. — **Competing lines.** — The dividing up of France into large regions served by different companies has avoided, except in a few rare cases, all competition between the internal lines. When there is any competition it is due to the radiating lines becoming mixed up at their ends (table 82).

The difference in the length of the journey prevents any competition between Paris and Belfort or Clermont-Ferrand, but the case is different between Paris and Bordeaux.

The special situation of the (Paris) Nantes to Landerneau line which penetrates a long way into the *State* Railways' territory is similar to that found in England in the Exeter, Plymouth and Ilfracombe district. But as from this year competition has stopped and as the result of an agreement made between the *Paris-Orleans* and the *State* Railways, the express trains from Paris run over this latter Company's lines as far as Redon, whence they continue to Landerneau on the Paris-Orleans line. The distance by this joint route is only 702 km. (436 miles).

More recently a more radical measure was decided upon and the *State* has taken over, as from the 1st January 1934, the operation of the Briton system of the *Orleans Company,* which includes the line from Savenay to Landerneau and its branches.

However, if there is no internal competition, international competition is very great in certain directions.

First of all, this is the case with the services between Paris and London via Folkestone, Calais, Boulogne (all ports on the Nord system), Dieppe or Le Havre

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(1) The Vallorbe line runs through the Jura by the Mont d'Or tunnel which is 6 100 m. (20 013 feet) long and lies between Frasne and Vallorbe.

The Geneva line between Bellegarde and Geneva runs through the Credo tunnel which is 3 949 m. (12 957 feet) long.

The single-track line from Bourg to La Cluse, and from thence to St. Julien and Geneva, has a tunnel 2 551 m. (8 370 feet) long.

Finally the Modane line runs through a series of tunnels, the longest of which are those of Mont-Lépine (3 062 m. = 10 046 feet) between St. André-le-Gaz and Chambéry, and the Mont-Cénis tunnel (13 600 m. = 8.45 miles) between Modane and Bardonecchia.

The Lyons to Briançon line, which is quite close to the above, passes under the Cabre pass by means of a tunnel 3 763 m. (12 346 feet) long between Livron and Briançon.

Further south, the Nice to Coni line passes through the Brauss pass tunnel, which is 5 939 m. (19 485 feet) long and that of Mont-Grazian 3 888 m. (12 756 feet) long.

TABLE 82.

DISTANCES BETWEEN PARIS AND THE PROVINCES BY COMPETING ROUTES.

RUN.	Companies.	Distance	
		Km.	Miles.
Paris, Est-Belfort	Est.	443	275.3
Paris, P.-L.M.-Belfort.	P.-L.-M.	503	312.6
Paris, P.-L.-M.-Clermont-Ferrand.	P.-L.-M.	420	261.0
Paris, Quai d'Orsay-Clermont-Ferrand	P.-O.	509	316.3
Paris, Quai d'Orsay-Tours-Bordeaux	P.-O.	588	365.4
Paris, Montparnasse-Saumur-Bordeaux	State.	615	382.1
Paris, Quai d'Orsay-Tours-Nantes	P.-O.	431	267.8
Paris, Montparnasse-Le Mans-Nantes	State.	397	246.7
Paris, Montparnasse-Nantes-Landerneau	P.-O.	770	478.5
Paris, Montparnasse-Rennes-Landerneau	State.	605	375.9

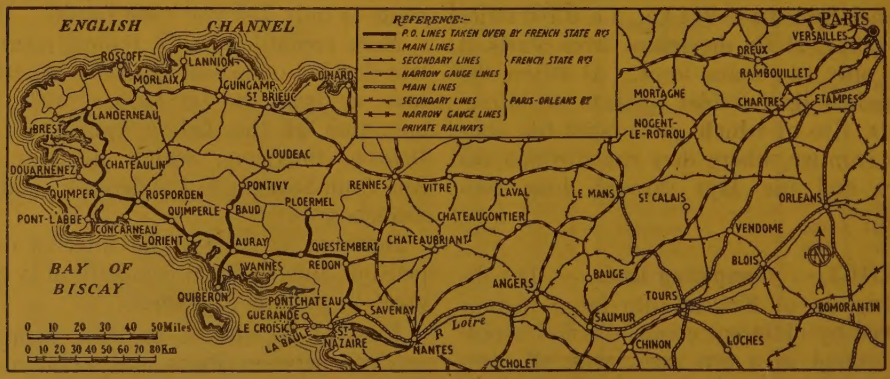


Fig. 33*. — Paris-Orleans lines in State Railways territory, now transferred to the latter Administration.

(belonging to the *State* Railways). We have given the details in table 12.

From London to Germany, the Calais, Lille (*Nord* system), Brussels, and Cologne line is in competition with that from Ostend (cf. table 14).

From Paris to Vienna the « Orient Express » and the « Arlberg Express » both run over the *Est* and the *Alsace-Lorraine* Railways, one of them going via Strasbourg and the other via Basle (cf. table 19). But as regards the Near East these two lines are in competition with the « Simplon-Orient Express » which runs over the *P.L.M.*'s lines.

Finally the French sections of two

(*) This map is reproduced from *The Railway Gazette*.

main lines to Madrid, by Hendaye or by Port-Bou are both part of the *P.-O.* and *Midi* systems.

The *Alsace-Lorraine* Railways differ from the other French systems in that their main line trains have two distinct destinations. This is due to the fact that this System deals with a longitudinal traffic current from Dunkirk, Holland and Belgium towards Basle, and a cross-country traffic as an extension of the radiating line coming from Paris, and directed towards Germany.

The trains from Holland to Basle through Belgium and Alsace-Lorraine are in direct competition with those of the right bank of the Rhine. On the other hand, the services from Calais and especially those of Dunkirk to Basle endeavour to capture the Anglo-Alsacian traffic and divert it from Belgium to the benefit of the French ports. The result has been that the express services of the *Alsace-Lorraine* Railways have been particularly well developed although it is a System that does not serve the capital.

While Alsace-Lorraine was part of the German Empire the speed of the trains, governed by the Imperial regulations, was kept within modest limits. But since the country came under the French flag, their maximum speed has been increased to 120 km. (74.5 miles) an hour. Although this has only been allowed within the last two years, the *Alsace-Lorraine* have made such good use of the authorisation that to-day they operate the French train with the highest overall speed.

Finally it was also on account of the change in ownership that the longitudinal services had to be speeded up and improved, so as to attract and keep in Alsace-Lorraine part of the traffic. In fact, when the lines of the two banks of the Rhine which assure the Basle-Amsterdam services were under the same central administration at Berlin, there could be no competition between them. The case of the services between England and Alsace was identical, since the arrangement of the timetables and rates enabled the Imperial government to favour traffic through Belgium to the detriment of Dunkirk and the French ports. To-day the situation is reversed, and the Anglo-Alsacian traffic goes via Dunkirk or Calais and remains on the French side of the Belgian frontier. The only traffic of any importance between Basle and Belgium is that from Antwerp and Holland to which must be added the unimportant remaining traffic from Basle to the Belgian coast.

XIII-4. — **Alternative lines.** — Because of the very constitution of the French railways there are no more alternative lines than there are competing lines. Almost the only case is on the *P.L.M.* where one of the alternative lines between Paris and Lyons, Paris and Tarascon or Lyons and Marseilles goes through so hilly a country that it is not fitted for fast express services.

In spite of some heavy gradients which have been maintained it was necessary to bore a series of long tunnels and even to have recourse to a helicoidal tunnel between Moulins and Lyons (1).

In addition to this, there are two different lines running out from Paris, of much the same standard of construction, to some places in the outer suburbs.

Of the two lines from Paris to Brussels, the Douai-Valenciennes line is too long,

(1) The longest tunnels on the line are those of Les Sauvages which is 2 938 m. (9 640 feet) long, between Roanne and Lyons, and the Echarmeaux (4 153 m. = 13 590 feet) between Paray-le-Monial and Givors.

TABLE 83.

ALTERNATIVE LINES.

RUN		Company.	Distance	
From	to		Km.	Miles.
	MAIN LINES.			
Paris Nord.	Aulnoye-Mons (Brussels)	Nord.	250	155.3
Do.	Valenciennes-Mons (Brussels)	Do.	314	192.8
Paris Est.	Châlons-Amanvilliers-Metz	Est-A.-L.	351	218.1
Do.	Châlons-Thiaucourt-Metz	Do.	411	255.4
Do.	Nancy-Metz	Do.	411	255.4
Calais Mar.	Lille-Hirson-Strasbourg-Basle	N.-E.-& A.-L.	727	451.8
Do.	Amiens-Laon-Chaumont-Basle	Do.	783	486.6
Paris P.-L.-M.	Dijon-Lyon	P.-L.-M.	512	324.4
Do.	Nevers-Lyon	Do.	508	315.6
Paris P.-L.-M.	Lyon-Valence-Tarascon	P.-L.-M.	763	474.1
Do.	Clermont-Ferrand-Tarascon	Do.	752	467.1
Lyons-Perr.	Arles-Marseille	P.-L.-M.	291	180.8
Do.	Grenoble-Marseille	Do.	307	190.8
	OUTER SUBURBS.			
Paris Nord.	Chantilly-Creil	Nord.	61	37.9
Do.	Pontoise-Creil	Do.	73	45.4
Paris Est.	Noisy-le-Sec-Verneuil-l'Etang	Est.	53	32.9
Do.	Champigny-Verneuil-l'Etang	Do.	55	34.0
Paris P.-L.-M.	Moret-Montargis	P.-L.-M.	118	73.3
Do.	Malesherbes-Montargis	Do.	126	77.3
Paris P.-L.-M.	Villeneuve - Brunoy - Melun-Fontainebleau-Montereau	P.-L.-M.	79	49.1
Do.	Villeneuve-Corbeil-Melun-Hericy et Montereau.	Do.	95	59.0
Paris St-Laz.	Argenteuil-Mantes	State.	58	36.0
	Poissy-Mantes	Do.	58	36.0

being 356 km. (221.2 miles) instead of 311 (193.2 miles) by the usual route.

As for the lines from Calais or Dunkirk to Basle via Hirson or via Laon, the technical conditions of this latter route give it such an advantage over the Hirson route that although it is considerably longer, it is the only one served by express trains.

XIII-5. — **Cross-country lines** (fig. 34). — Although they are less numerous and above all less important than on the English railway systems, the French cross-country lines are nevertheless just as interesting, though most of them are necessarily inter-company lines.

Nord, *Est* and *Alsace-Lorraine*. — In the north-east there are two lines of this

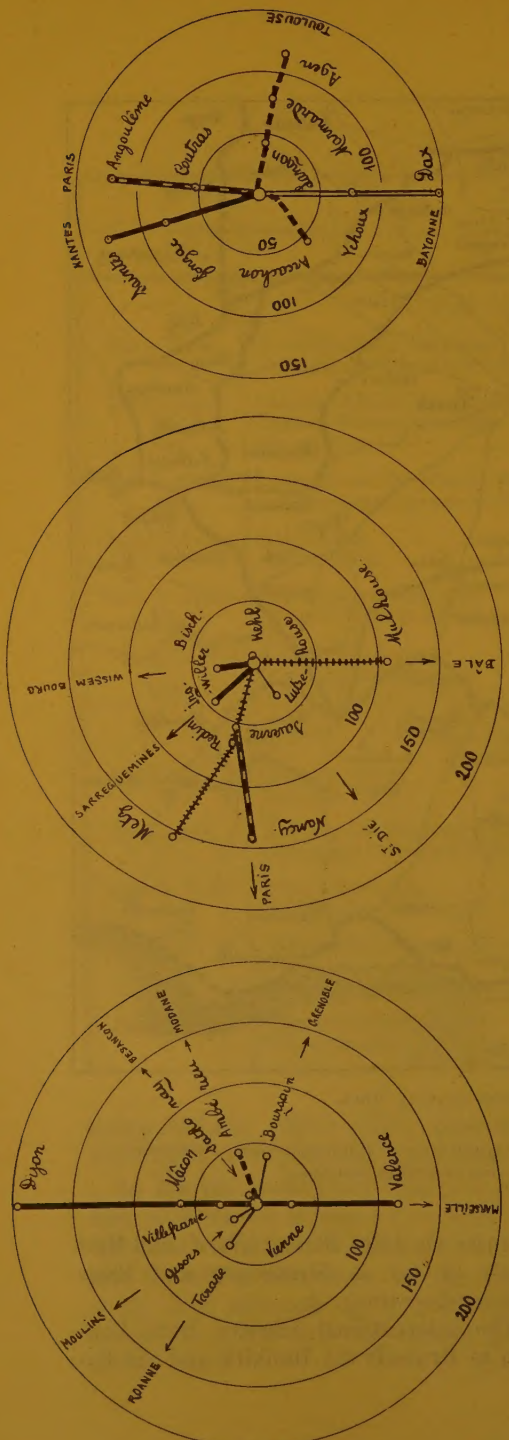
Fig. 34. — French main cross-country lines.

Explanation of French terms :
Lignes transversales = Cross-country lines. — Lignes rayonnantes = Radiating lines. — Sections communes, etc.... = Cross-country and radiating sections.

sort, which facilitate communications, between the ports of the Straits of Dover, Basle and beyond.

The first is a boundary line which from Calais or Dunkirk runs along the Belgian frontier via Lille, Hirson (*Nord*) and Metz (*Est*) as far as Strasbourg and Basle (*Alsace-Lorraine*).

The international services from London to Brussels via Dunkirk and via Ca-


TOULOUSE
Agen
Périgueux
Angoulême
Bordeaux
Dax
PARIS
NANTES
BAYONNE
Limoges
Arcachon
Ychoux
50
100
150
PARIS
Nancy
Metz
Mulhouse
Belfort
Dijon
Modane
Culoz
Bourg
Macon
Lyon
Valence
Vienne
Givors
Tarare
Villefranche
Roanne
Moulins
Marseille
Grenoble
Besanç

parallel », is run over by one of the important French trains, the « Milan-Bordeaux », and for some time was also used by a section of the « Simplon-Orient Express ».

P.L.M. and *Midi.* — Further south there is another boundary line which in this case follows the southern frontier of France, first of all along the Pyrenees, and then along the Mediterranean coast. This is the main line of the *Midi* Railway from Bordeaux and Bayonne to Toulouse, Narbonne and Sète, where the *P.L.M.* continues it through Nîmes to Marseilles and Ventimiglia.

The *State* and *Midi* Railways. — Because of the layout of their system, into which has been incorporated the former *Ouest* Railway, the *State* Railways are able to establish important diagonal services within their own territory. This was the case when they set up the services from Dieppe and Saint-Malo to Nantes, which are continued to Saintes and Bordeaux. In Summer, the *Midi* runs these services as far as the Spanish frontier.

The main line and each of the two branches of this fork are run over by the express trains of the *State* Railways :

a) the « Côte d'Emeraude-Pyrénées Rapide » which runs between St-Malo and Bordeaux, and in Summer, goes as far as Irun;

b) the « Manche Océan Rapide » which starts from Dieppe Harbour where it picks up the English traffic which it takes to Bordeaux, and in Summer, as in the case of the former, is continued as far as the Spanish frontier.

TABLE 84.

A FEW CROSS-COUNTRY LINES.
(Fig. 34.)

COMPANY AND RUN.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h	
NORD.							
Calais to Saint-André (Brussels).	103	64.0	R 10.50 a. m.	1.07	92.2	57.3	Pullman.
ALSACE-LORRAINE.							
Basle-Strasbourg and Luxembourg.	365	226.8	9.20 a. m.	3.56	92.8	57.7	Edelweiss.
Mulhouse-Strasbourg	109	62.7	9.44 a. m.	1.01	107.2	66.6	Do.
Strasbourg-Metz	159	98.8	10.50 a. m.	1.32	103.7	64.4	Do.
MIDI.							
Bordeaux to Sète	426	264.7	7.28 a. m.	7.17	58.3	37.9	
STATE.							
Saint-Malo-Nantes-Bordeaux S. J.	516	320.6	7.30 a. m.	8.51	58.4	36.2	Côte d'Emeraude-Pyrénées.
Dieppe-Nantes-Bordeaux S. J. . .	845	525.1	R 10.10 p.m.	14.45	57.3	35.6	Manche-Océan.

Strasbourg, Lyons and Bordeaux are so far from Paris that these towns are important secondary centres with their own radiating services :

From Strasbourg to Dunkirk;
From Strasbourg to Lyons and Marseilles;
From Lyons to Strasbourg;
From Lyons to Bordeaux;
From Lyons to Saint-Nazaire;

From Bordeaux to Nantes and Saint-Malo;
From Bordeaux to Nantes and Dieppe;
From Bordeaux to Lyons;
From Bordeaux to Marseilles.

TABLE 85

SOME INTER-COMPANY THROUGH TRAINS.

(Fig. 34.)

COMPANY AND THROUGH TRAIN SERVICES.	Distance		Time of departure.	Time spent.	Speed		
	Km.	Miles.			Miles/h.	Km./h.	
NORD, EST. and ALSACE-LORRAINE.							
Dunkirk-Hirson-Strasbourg . . .	706	438.7	6.28 a.m.	8.13	85.3	53.0	
Boulogne-Laon-Chaumont-Basle .	738	458.6	5.46 p. m.	8.52	83.2	51.7	Winter.
Calais do. do. do. . .	783	486.6	7.42 p. m	9.18	84.2	52.3	
Etaples-Laon	204	125.8	6.14 p. m.	2.13	92.0	57.2	
Laon-Chaumont	243	150 1	8.34 p. m.	2.46	87.8	59.1	Winter.
Laon-Châlons.	109	67.7	8.34 p. m.	1.18	83.8	52.1	Summer.
Lille-Chaumont-Dijon	506	314.4	R 2.40 p. m.	8.21	60.5	37.8	
Boulogne - Châlons - Nancy - Strasbourg	670	416.3	5.46 p. m.	8.34	78.2	48 6	Orient-Express.
NORD and BELGIAN RAILWAYS.							
Paris N.-Liége Guillemins . . .	367	228.1	10.10 a. m.	3.50	95.7	59.4	
Paris N.-Brussels Midi	311	193.1	11.25 a. m.	3.15	95 7	59.4	Etoile du Nord.
ALS.-LORR., EST and P.-L.M.							
Strasbourg-Belfort-Lyons	474	294.6	11.06 p. m.	7.54	60.0	37.3	
P.-L.-M. and P.-O.							
Lyon Saincaize-St-Nazaire . . .	803	499.0	7.45 a. m.	11.08	72.1	44.7	
Lyon-Gannat-Limoges-Bordeaux .	626	389.0	7.10 p. m.	12.38	49.8	30.9	Milan-Bordeaux.
STATE and P.-O.							
Paris-Redon-Landerneau	702	436.2	8.20 p. m.	13.03	53.7	33.3	
MIDI and P.-L.-M.							
Bordeaux-Narbonne-Vintimille . .	941	584.7	5.15 p. m.	16.38	56.6	35.2	
STATE and MIDI.							
Dieppe-Nantes-Bordeaux-Hendaye.	1077	669.2	R 5.33 p. m.	19.22	57.6	35.8	Manche-Océan.
St-Malo-Nantes do. do. .	751	466.6	8.08 a. m.	12.23	60.7	37.7	Pyrénées-Côte d'Argent Exp.
P.-O. and MIDI.							
Paris-Bordeaux H.	814	505.8	11.00 a. m.	9.58	83.1	51.6	Sud Express.
Paris-Narbonne-Port Bou. . . .	973	603.6	12.15 night	9.17	65.0	40.4	Barcelone Exp.
Marseille-Port Bou.	382	237.3	8.15 p. m.	8.01	47.8	29.7	

The above are cross-country lines when considered in their relation to the whole system, but unlike when starting from Paris, relatively few non-stop services running any distance start from such secondary centres, as the local traffic is not sufficient to justify this (cf. fig. 35).

We have already said how the line from

Paris to Landerneau, which was operated separately by the *State* and *Paris-Orleans* Railways, has latterly become a joint line, taking advantage of the shortest route over each of the two systems.

Finally it is well to remember that most of the trains from Paris-Est to Alsace-Lorraine are inter-company ones, just as those over the main lines of the *Paris-Orleans* Railways to the Pyrenees, which end their journey on the lines of the *Midi* Railway.

XIII-6. — **Forks.** — On the *Nord* and *Est* Railways there is a characteristic fork line, similar to those of the *L.M.S.* in England. The important trains from the East divide up in fact over the French route so as to go either to Paris, or to London via Calais or Boulogne. The division takes place at Chaumont for the trains coming from the East, the Arlberg or Switzerland, and at Châlons-sur-Marne in the case of trains from southern Germany; both of them then proceed to Rheims, Laon and Amiens where they join up with the Calais line. This route is followed by the « de luxe » trains and some fast expresses.

The *State* Railways also have an interesting fork : the main line from Bordeaux divides up at Mantes to go to either Dieppe or Saint-Malo, these routes being followed respectively by the « Manche-Océan » and the « Pyrénées-Côte d'Emeraude » expresses, two important inter-provincial trains of this Administration.

XIII-7. — **Watering places, seaside and holiday resorts.** — During the season, these places are served by through fast expresses from Paris, but unlike what happens in England, there are few trains from other parts of the country. Of course, as on the other side of the Channel, there are services of through coaches from some provincial centres, but in France there is not the multitude of trains from all parts of the country which is found in Great Britain.

An exception must however be made in the case of the Côte d'Argent and the Côte d'Azur which are served much better. The first is connected to Paris by the *Paris-Orleans* and to Saint-Malo and Deauville by the *State*. As for the second, it is served by trains from different parts of the interior and from abroad. There are through trains from Calais, Paris, Bordeaux, Strasbourg and Geneva (via Lyons) and a series of « de luxe » trains from Calais-Paris, Rome, Berlin, Vienna and Milan, and formerly also from Saint-Petersburg and Amsterdam.

CHAPTER XIV.

The trains.

XIV-1. — **Generalities.** — We do not claim to give a complete study of the French train services : we shall limit ourselves to a few remarks, particularly as regards their speed.

The main lines — and only the main lines — are run over by fast express trains, most of which are made up of rolling stock belonging to the companies themselves and some of them, some of the most important in fact, of stock belonging to the *International Sleeping Car Company*. Many of these trains are limited trains, which we will consider first of all.

The boat trains form a second important group.

Competition of road transport has forced the railway companies to pass from the defensive to the offensive, which explains the putting into service of an interesting series of accelerated trains.

TABLE 86.

SEASONAL SERVICES TO SEASIDE AND HEALTH RESORTS.

COMPANY AND RUN.	Distance		Time of departure.	Time spent.	Speed		
	Km.	Miles.			Km /h.	Miles/h.	
NORD.							
Paris N.-Etaples.	227	141.0	10.00 a. m.	2 13	102.4	63.6	
Do. Le Tréport.	183	113.8	R 7.28 p. m.	2.37	70.0	43.5	
STATE.							
Paris-S.-L.-Saint-Valéry	202	125.5	4.35 p. m.	2.45	75.3	46.8	Slip coaches.
Do. -Etretat.	230	142.9	Do.	3.04	75.0	46.6	Do.
Do. -Deauville	221	137.3	1.50 p. m.	2.00	110.5	68.7	Railcars.
Do. do. -Dives.	239	148.5	Do.	2.31	95.0	59.0	Do.
Paris M.-Briouze-Bagnolles . . .	256	157.0	11.20 a. m.	3.55	65.4	40.6	
Do. -Saint-Malo	456	289.3	12.05 noon	5.52	77.7	48.2	
Do. -Dinard.	471	292.7	1.15 p. m.	7.04	67.2	41.7	
Do. -Lanion.	549	338.0	Do.	7.20	95.0	59.0	
Bordeaux S. J.-Royan	167	103.8	5.17 p. m.	2.02	82.2	51.1	
Do. S. L.-Pte de Grave. . .	103	64.0	2.04 p. m.	1.43	60.0	37.3	
Do. S. J.-Arcachon. . . .	96	59.6	1.21 p. m.	1.48	44.0	27.3	
Paris M.-Les Sables d'Olonne . .	476	293.3	3.00 p. m.	7.05	67.2	41.7	
Do. -Le Pornic.	459	285.2	10.25 p. m.	8.35	53.5	33.2	
Do. -La Rochelle	467	290.2	12.10 noon	6.19	74.0	46.0	
Do. -Royan	526	326.8	Do.	6.50	77.0	47.8	
Do. -Rochefort-Fourras. . .	493	306.4	Do.	7.03	70.0	43.5	
PARIS-ORLÉANS.							
Paris Q. O.-Biarritz.	799	496.4	11.00 a. m.	9.15	86.4	53.6	Sud Express.
Do. -La Baule	515	320.0	12.35 noon	6.57	74.1	46.0	
Do. -Le Croisic.	524	323.5	7.20 a. m.	6.58	75.2	46.7	
Paris Q. O.-Royat.	504	313.2	10.35 a. m.	10.49	46.6	29.0	
Do. -Mont-Dore	476	295.7	Do.	8.09	56.2	34.9	
Do. -Néris-les-Bains. . . .	338	210.0	Do.	5.00	67.4	41.8	
Do. -Vic-sur-Cère.	579	359.8	7.22 p. m.	11.13	51.6	31.8	
Bordeaux-Mont-Dore	205	127.4	R 10.06 a. m.	7.54	25.9	16.1	
Lyons-Mont-Dore.	...	...	...	...	...	...	
P.-L.-M.							
Paris P.-L.-M.-Vichy	365	226 8	11.00 a. m.	4.50	76.5	47.5	
Metz-Vichy.	541	335.5	8.50 a. m.	9.20	54.9	34.2	
Paris P.-L.-M.-Vals-les-Bains. . .	687	429.9	R 11.25 a. m.	10.25	66.3	41.2	
Paris P.-L.-M.-Evian	650	403.9	8.20 a. m.	10.55	55.0	34.2	
Do. -Aix-les-Bains . . .	560	348.0	8.40 p. m.	7 53	72.0	44.7	
Do. -Chamonix	714	443.7	8.00 p. m	12.40	56.0	34.8	
Do. -Grenoble.	633	393.4	9.10 p. m.	9.40	65.5	40.7	
Do. -Briançon	861	535.0	Do.	14.35	59.1	36.7	
EST.							
Paris E.-Vittel	371	230.5	10.20 a. m	5.10	71.8	44.6	
Do. -Bourbonne-les-Bains . .	354	220.0	Do.	5.03	70.1	43.5	
Do. -Gérardmer	461	286.4	Do.	6.59	65.9	41.0	
Do. -Blombières	402	249.8	Do.	5.36	71.2	44.2	
MIDI.							
Paris Q. O.-Lamalou-les-Bains . .	850	528.2	7.20 p. m.	12 51	66.2	41.1	
Do. -Bagnères-de-Bigorre. .	917	569.9	Do.	15.01	60.1	37.3	

These consist first of all of the local trains, and then of a new class of train : the « light trains » whose speed must be noted.

Then there are railcars, which are a recent development but are already used for many local services, and for fast and even fast express services.

Mention must also be made of the goods trains and of a class of train that is still found on certain French and Spanish lines : the mixed trains.

Finally a special chapter should be devoted to the French services of the *International Sleeping Car Company.*

XIV-2. — **Limited trains.** — Besides trains made up of stock belonging to the *International Sleeping Car Company,* there are a certain number of other limited trains. First of all there are the fast express trains run by the Companies, three of which start from Bordeaux: the « Pyrénées-Côte d'Emeraude » and the « Manche-Océan » belonging to the *State* Railways, and the « Bordeaux-Milan Rapide » run by the *Paris-Orleans* and the *P.L.M.;* the latter has taken over the section of the « Simplon-Orient » which formerly gave this service.

On the other hand, the « Côte d'Azur Rapide » and the « Sud Express » run by the *P.L.M.* and the *Paris-Orleans* Railways are composed entirely of Pullman cars.

Furthermore, certain seasonal trains run in the Summer to serve health or seaside resorts are also limited trains. Table 87 gives some examples.

TABLE 87.

A FEW LIMITED TRAINS.

COMPANY AND RUN.	Distance		Time of departure.	Time spent.	Speed		
	Km.	Miles.			Km./h.	Miles/h.	
EST.							
Paris-Vittel	371	230.5	10.20 a. m.	5.10	60.2	37.4	
STATE.							
Paris-Mantes-Havre.	228	141.7	4.35 p. m.	2.33	89.3	55.5	
Do. -Saint-Valéry . . .	202	125.5	Do.	2.45	73.5	45.7	
Do. -Fécamp	223	138.9	Do.	2.48	79.6	49.5	Slip coaches.
Do. -Froberville-Etretat .	220	136.7	Do.	2.48	78.5	48.8	

XIV-3. — **Ports and boat trains.** — Separate mention must be made of the ports for the cross-Channel services and those for the transatlantic or transmediterranean services, as the trains meeting the boats have different characteristics in each case. For convenience, they may be grouped into three classes : services radiating from Brussels or Paris, the other services to or from the interior of the country, and finally the international services.

The radiating services are run regularly to the Channel ports and recently to the Mediterranean ports also.

TABLE 88.

FRENCH PORT SERVICES.

COMPANY.	PORT	Maritime service.	Destination of trains.
			a) RADIATING LINES.
Nord.	Dunkirk.	Folkestone.	From Paris and Brussels.
Do.	Calais.	Dover.	Do.
Do.	Boulogne.	Folkestone.	Do.
State.	Dieppe.	Newhaven.	Only from Paris.
Do.	Havre.	Southampton.	Do.
P.-O.	Port-Vendres.	Algeria.	Do.
P.-L.-M.	Marseilles.	North Africa.	Do.
			b) OTHER INTERNAL SERVICES.
Nord.	Dunkirk.	Folkestone.	Nancy or Strasbourg-Basle.
Do.	Calais.	Dover.	Laon, Belfort and Basle. (« Calais-Delle » train).
Do.	Boulogne.	Folkestone.	Laon, Belfort and Basle.
State.	Dieppe.	Newhaven.	Nantes, Bordeaux and Hendaye (« Manche-Océan »).

In the case of traffic to and from the interior, regular boat trains are only run between Paris (and Brussels) and the ports on the Channel and Mediterranean :

Calais (Boulogne)-Paris Nord	450 to 600 t. (442 to 590 Engl. tons).
Do. -Brussels	410 to 510 t. (403 to 502 Engl. tons).
Do. do. (Pullman). . . .	305 t. (300 Engl. tons).
Do. -Laon, Basle	520 to 620 t. (512 to 610 Engl. tons).
Do. -Lille, Hirson, Basle . . .	465 t. (457 Engl. tons).
Dunkirk Mar.-Paris-Nord	390 to 435 t. (384 to 428 Engl. tons).
Do. -Lille, Hirson, Basle.	465 t. (457 Engl. tons).

During the 1930 Summer, the Tilbury-Dunkirk service was still in connection with a series of continental express trains, the first of which left the harbour station at 6.15 a.m. for Basle, the first stop being Hirson (1); the second left at 6.25 a.m. for Paris, and only stopped at Dunkirk-Town (2); the third at 6.30 a.m. for Lille with through coaches for Basle and Brussels, and finally the fourth at 6.35 a.m.

(1) After Hirson it only stopped at Longuyon, Metz, Strasbourg, Mulhouse, and Basle, where it arrived at 3.30 p.m., with an extension to Milan (arriving at 11.40 p.m.) and a coach for Lucerne. Another section went to Interlaken (in 1929) via Nancy, Lure and Delle.

(2) It arrived at Paris at 10 a.m., having taken 200 minutes to cover the 189.5 km. (117.7 miles), *i. e.* with an overall speed of 91.4 km. (56.8 miles) an hour. One coach went directly through Paris to Lyons, making use of the Paris Ceinture Railway.

Table 89.

BOAT TRAINS.
(Fig. 36.)

PORT	TRAINS TO	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	
Radiating lines.								
Dunkirk Harb.	Brussels M.	192	119.3	8.46 p. m.	3.26	55.3	34.4	
Calais Harb.	Do. Q.-L. and N.	226	140.4	R 9.03 a. m.	2.54	77.9	48.4	**Pullman Exp**
Boulogne Harb.	Do. do.	258	160.3	5.35 p. m.	3.24	75.9	47.4	Do.
Dunkirk Harb.	Paris N.	312	193.8	6.15 p. m.	3.45	83.2	51.7	Stops at Hazeb. and Dover T.
Calais Harb.	Do	299	180.8	R 10.00 a. m.	3.05	**94.4**	**58.7**	Golden Arrow.
Boulogne Harb.	Do	254	157.8	t 4.40 p. m.	2.34	**98 9**	**61.6**	
Do.	Paris P.-L.-M.	266	161.8	8 35 p. m.	3.17	81.1	50.4	
Dieppe.	Paris St-Laz.	169	105.0	R 10.15 a. m.	2.26	**69.4**	**43.1**	
Havre.	Do	228	141.7	R 7.55 p. m.	2.40	85.5	53.1	
Cherbourg.	Do	239	148.5	10.20 a. m.	4.28	83.0	51.6	
Port-Vendres Q.	Paris Q. O.	960	596.5	R 10.20 a. m.	14.20	69 0	42.9	Barcelone Exp.
Marseilles Harb.	Paris P.-L.-M.	860	534.4	11.49 a. m.	11.03	73.3	45.6	Since 14-6-33.
Transverse lines.								
Dunkirk Harb.	Nancy	468	293.8	7.07 a. m.	10.31	65.7	40.8	
Do.	Strasbourg-Basle	732	434.8	Do.	10.20	71.1	44.1	
Calais Harb.	Laon-Basle.	783	486.6	7.42 p. m.	9.18	84.2	52.3	
	Hirson-Basle	761	472.9	R 8.50 p. m.	13.31	56.2	34.9	Summer.
Boulogne Harb.	Laon-Delle.	738	458.6	6.02 p. m.	9.52	74.8	46.5	Switzerland.
	Hirson-Basle	801	497.7	R 8.50 p. m.	14.19	55.9	34.8	Winter.
Dieppe.	Nantes-Bordeaux	845	525.1	3.34 p. m.	15.11	55.7	34.6	Manche-Océan.
Saint-Malo.	Do. do.	518	317.4	8.08 a. m.	8.15	62.8	39.0	**Côte d'Emer**
Marseilles (A.).	Paris-Calais	1 172	728.2	4.50 p. m.	18 45	62.5	38.8	**P. & O. Exp**
Do.	Do. -Boulogne	1 128	700.9	R 6.12 p. m.	18.13	61.9	38.5	Do.
Port-Vendres Q.	Bordeaux	503	312.6	R 10.08 p. m.	11.37	47.6	29.6	
International « de luxe » services.								
Calais Harb.	Laon-Strasburg	714	443.7	R 4.40 a. m.	8.45	81.6	50.7	Orient Express.
Do.	Do. -Belfort-Basle.	783	486.6	R 3.35 a. m.	9.50	79.2	49.2	Arlberg. Exp.
Do.	Paris-Vallorbe	779	484,1	R 2.25 a. m.	12.44	61.1	37 9	**Simplon-Orient Express.**
Do.	Do. -Modane	989	614.6	R 11.50 p. m.	15.35	63.5	39.4	Rome Express.
Do.	Do. -San Remo.	1 455	904.0	2.30 p. m.	23.04	63.1	39.2	Cal.-Médit. Exp.
Boulogne Harb.	Laon-Strasburg	669	415.7	5.46 p. m.	8.34	79.1	49.1	Orient Express.
Do.	Do. -Belfort-Basle.	738	458.6	5.46 p. m	8.44	84.5	52 5	Arlberg. Exp.
Some other international services.								
Calais Harb.	Laon-Belfort-Delle	722	448.6	R 1.36 a. m.	11.24	68.6	43.3	Switzerland.
Do.	Do. do. -Basle	783	486.6	R 12.25 night	11.24	69.9	42.9	Do.
Boulogne Harb.	Do. do. -Delle	738	458 6	6.02 p. m.	9.01	81.8	50.8	Do.
Marseilles Harb.	The Hague.	1 353	842.0	8.58 p. m.	21.10	64.0	39.8	Rotterdam. Lloyd Exp.

Fig. 36. — French boat trains.

was a semi-through train with 1st, 2nd and 3rd-class carriages (1).

Since then these trains have been considerably slowed down, however, and their number reduced to two only.

The international services (apart from

(1) This train served Lille, Arras, and other towns.
On the return journey the trains were due to arrive at Dunkirk at 12.14, 12.23, 12.30 (night) and 1 a. m. This last train left Basle at 3.12 p. m. and Milan at 6.50 a. m., and the time of arrival at St. Pancras was 9.27 a. m.

those to and from Brussels) generally include coaches for beyond Paris or Belgium. The « de luxe » trains dealing with the London traffic are continued to Switzerland, Italy and the Near East : we will deal with them in greater detail later on.

The train from Dieppe to Paris is run via Pontoise in Summer and via Rouen in Winter, so as to maintain the connection with Bordeaux which the « Manche-Océan » provides in Summer. This increases the length of the journey from 169 to 201 km. (105 to 125 miles).

The **transatlantic boat trains** are generally booked according to schedules varying with the time of arrival of the mail boats.

Thus the « Rotterdamsche Lloyd Express » which runs every three weeks between The Hague and Marseilles, via Brussels-Midi and Paris-Gare de Lyon, follows a fixed timetable on the outward journey, but on the return journey has the choice of four timings; it takes from 21 h. 10 m. to 22 h. 47 m. to cover the distance.

This train is made up of 1 to 4 sleeping cars and a restaurant car belonging to the *International Sleeping Car Company*, in addition to the rolling stock belonging to the railway companies.

The *Paris-Orleans* has no transatlantic boat trains. On the opening of the pier at Verdon on the 22nd July, 1933, a special train was exceptionally run between Bordeaux St. Jean and Paris (1).

In the case of the services between Paris and Algeria via Port-Vendres three carriages for Port-Vendres (Quay) are attached to one of the Company's regular express trains (2).

On the *State* Railways, transatlantic boat trains are run between Paris, Cherbourg, Havre and Boulogne, which connect with the steamers for North and South America, and between Paris and Bordeaux for the liners to South and Central America. Too few passengers disembark at La-Rochelle-Palice to justify the continued running of the former special transatlantic boat trains.

All these trains include a restaurant car belonging to the *International Sleeping Car Company* and, for the last few years, have been made up of special stock belonging to the *State* Railways, the service being assured by the *International Sleeping Car Company* (fig. 37). Below we give figures showing the utilisation of these trains during the last half-dozen years.

Year.	Passengers.	Number of trains.
1927	196 261	—
1928	189 337	1 135
1929	188 777	1 194
1930	180 665	1 191
1931	134 607	914
1932	114 627	754
Up to August 1933.	58 139	—

On certain days, such as the 7th June, 1929, as many as 14 transatlantic boat trains arrived at Paris-Saint-Lazare, six of which came from Cherbourg with passengers from the « Majestic » alone, and one left; on the 14th June there were 8 arrivals and one departure; on the 7th September, 11 departures and 2 arrivals.

(1) A train of 13 carriages weighing altogether 540 t. (531 Engl. tons) left Bordeaux at 10.30 a. m. and arrived at Paris Quai d'Orsay in 5 h. 44 m. with 5 intermediate stops.

(2) Two composite « couchettes » cars and one third-class carriage.

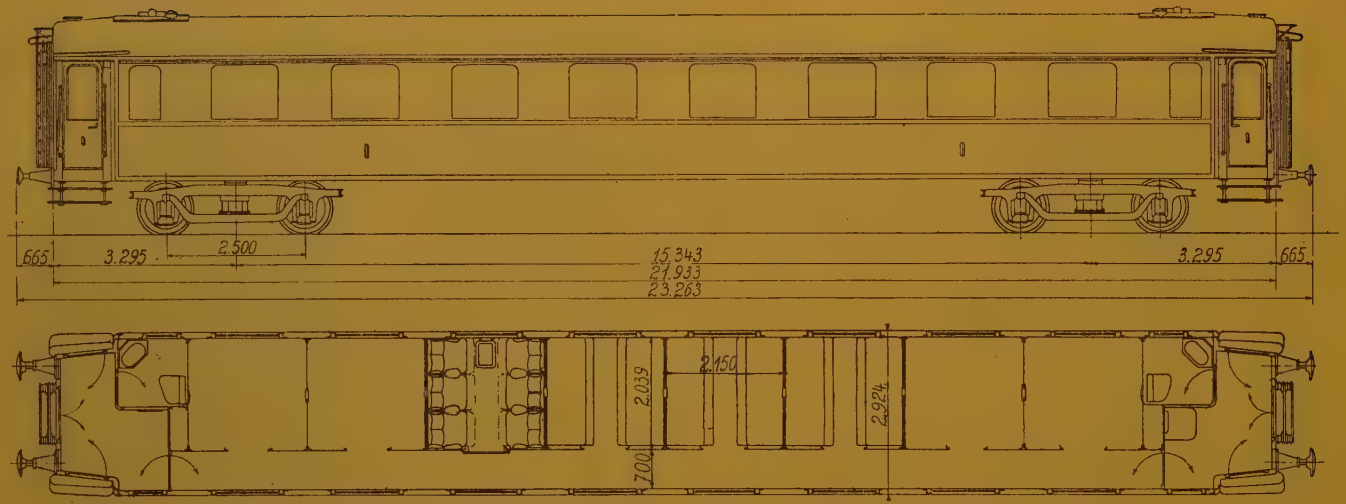


Fig. 37. — First-class « couchettes » carriage. — State Railways.

Fig. 37*b*. — Cross section of a 1st-class compartment and of a « couchettes » compartment. — State Railways.

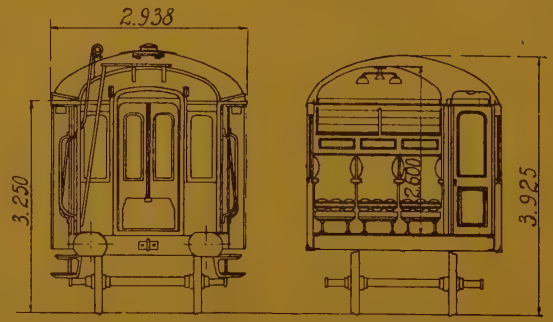


Fig. 37*c*. — End view and cross section of 1st-class carriage. — State Railways.

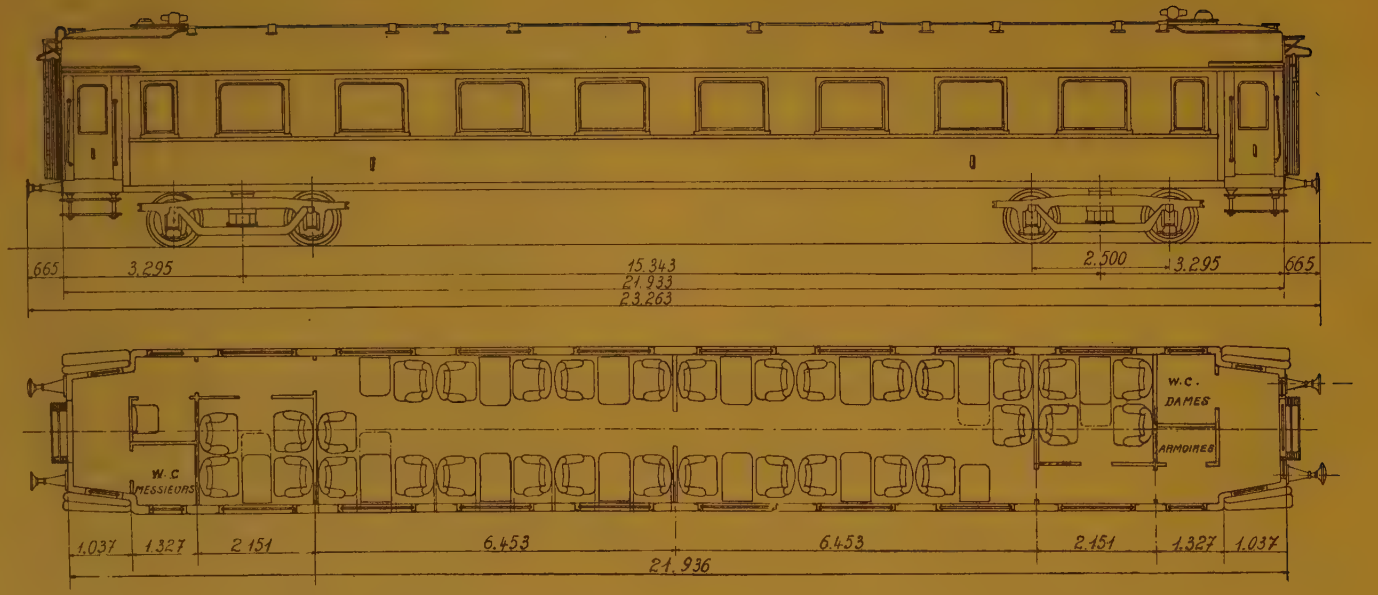


Fig. 38. — First-class « transatlantic » carriage (Pullman type). — State Railways.

The new transatlantic stock (Pullman carriages) of the *State* Railways was put into service in 1931, and on certain days, in spite of the constant decline in the number of passengers, it had to deal with a heavy traffic (fig. 38).

On the 12th June, 1931, for example, there were two Pullman trains for the « Ile de France », the first made up of 8 Pullman cars (4 pairs), the second, three pairs and two second-class carriages.

On the 2nd October, when the « Bremen » sailed, the train consisted of 10 Pullman coaches (5 pairs).

On the Havre line, the fastest transatlantic boat train (leaving at 8.23 a.m.) takes 2 h. 52 m. to cover, non-stop, the 229 km. (142.3 miles) between Paris and Havre Harbour station, which corresponds to an average speed of 79.9 km. (54.7 miles) an hour. The weight of this train (August 1933), made up of 9 to 13 vehicles is 386 to 563 t. (380 to 554 Engl. tons). When the weight is below 400 t. (393 Engl. tons) it is hauled by a *Pacific* engine; above this weight à *Mountain* locomotive is used.

The fastest transatlantic boat train on the Cherbourg line (dep. at 10.20 a.m.) takes 4 h. 28 m. to reach the Harbour station, with a 3-minute stop at Caen. Its average speed is 82.8 km. (51.5 miles) an hour, and it weighs about the same as the previous train. It is composed of 8 to 14 vehicles weighing 337 to 372 t. (331.6 to 366 Engl. tons) and it is hauled by a *Mountain* locomotive when the weight is above 460 t. (453 Engl. tons).

XIV-4. — **Slip coaches.** — This system, which is falling out of use in England, has been used for a very long time in France, where, at any rate on the *State* System, its use appears to be growing again.

It was introduced in 1878, at Malaunay and at Beuzeville, during the seaside holiday season, and at Rambouillet during the hunting season. Apart from these seasonal cases, during the whole of the year the coaches for Le Pecq were slipped from the Paris to Saint-Germain train when running at full speed and were left at the bottom of the bank.

Since then, the system has been perfected, and it was used during the 1933 Summer for the new non-stop Paris-Havre express, three lots of coaches being slipped during the journey, the 1st at Motteville, and the 2nd and 3rd at Bréauté-Beuzeville for Saint-Valéry, for Fécamp and Etretat (1).

XIV-5. — **Accelerated local trains.** — The rearrangement of the timetables has been extended to these trains as well, seeing that it is perhaps even more important in their case as they are more immediately affected by road motor competition. Table 90 gives details of a few runs.

It will be noticed that the average speed is usually above 45 km. (28 miles) an hour including the stops. On the *Nord* Railway, for a train which stops 16 times, 13 minutes station time is allowed; on

(1) The express No. 197 leaves Paris at 4.35 p.m.

The Saint-Valéry portion leaves Motteville at 6.41 p.m. The Etretat and Fécamp portions leave Bréauté-Beuzeville together at 6.56 p.m. They are divided up at Ifs, one part leaving at 7.13 for Fécamp, and the other at 7.15 for Etretat.

The Havre portion consists of a brake van, two 3rd-class coaches and one 1st-class. The three other portions are each made up of one 1st-class coach, one composite coach and a van. Consequently there are 10 coaches when leaving Paris.

TABLE 90.

A FEW LOCAL TRAIN SERVICES.

COMPANY.	RUN.	Distance		Time of departure.	Time spent.	Speed		Number of stops.
		Km.	Miles.			Km /h.	Miles/h.	
Nord.	Amiens-Tergnier	80	49.7	9.44 a. m.	1.32	52.2	32.3	16
Est.	Vitry-le-François-Toul	115	71.4	9.40 a. m.	2.34	45.1	28 0	16
	Châlons/M.-Château-Thierry	78	48.5	1.22 p. m.	1.47	43.1	26.7	11
	Langres-Port d'Atelier	64	39.8	1.03 p. m.	1.25	45.2	28.1	8
Alsace (1).	Strasbourg-Wissembourg	68	42.2	12.15 night	1.31	44.8	32.3	14
	Strasbourg-Lauterbourg	56	34.8	7.59 a m.	1.16	44.2	27.4	9
	Béning-Metz	62	38.5	3.01 p. m.	1.20	46.5	28.9	10
P.-O. (1).	Etampes-Orleans	65	40.4	8.26 a. m.	1.21	48.2	29.9	9
	Orleans-Vierzon	82	50.9	9.23 a. m.	1.22	58.8	36.5	5
Midi (1).	Bordeaux-Morcenx-Dax	148	91.9	8.13 a. m.	3.16	45.3	28.2	20
State (1).	Rouen-Dieppe	61	37.9	10.48 a. m.	1.02	58.7	36.4	4
	Paris-Rouen	140	87.0	11.05 p. m.	1.56	49.0	30.4	8
	Paris-Le Mans	211	130.5	6.13 a. m.	4.42	45.0	28.0	18

the *Paris-Orleans* Railway one minute is allowed for every stop.

In order to achieve such tight timings, the trains have to be scheduled at fairly high speeds. On the *Est* Railway, the speed is 60 km. (37 miles) an hour, except for a few trains which run at 70 to 75 km. (43 to 46 miles) an hour; on the *Midi* the speed is 65 km. (40.4 miles) an hour.

The *Nord* Railway has completely revised all its local train services, 181 trains having been accelerated on the 2nd October, 1932, and the remaining 463 on the 15th May, 1933 (2).

On the secondary lines of this System, the average speed formerly was only 27 to 30 km. (17 to 19 miles) an hour, with stops in sufficiently populated districts every 3 or 4 km. Some of these lines were only served by 3 trains in each direction, the minimum allowed by the concession deed, instead of the 4 or 5 run before the War. Seeing that, in addition to this, the rolling stock was old-fashioned and uncomfortable, it was easy enough for the road motor services to compete successfully with the railway.

Forced to face the fact that its trains would soon be running completely empty, the *Nord* drew up a programme for the improvement of the services, the measures including acceleration to the extent that the overall speed was increased to

(1) 1932-1933 Winter.

(2) These trains working over 1 600 and 1 309 km. (994 and 808 miles) of line respectively, run daily 16 072 and 12 057 tr.-km. (9 947 and 7 492 train-miles).

The details which follow have been kindly supplied by the *Nord Railway Company* and have been completed by information obtained from a very detailed article by Mr. Barret, which appeared in the *Revue Générale des Chemins de fer* for July, 1933.

40 km. (25 miles) an hour in the case of steam traction and 50 km. (31 miles) an hour in the case of the railcars which it was decided to use instead of locomotives. However, the maximum regulation speed 80 km. (50 miles) an hour was retained, which the old compound 6-wheeled coupled engines with wheels 1.75 m. (5 ft. 8 29/32 in.) in diameter reach in 2 min. 15 sec. in a distance of 1 500 m. (1 640 yards), and from which speed they can stop in 500 m. (547 yards) with trains weighing about a hundred tons.

To make the timings more flexible, the control service raised the maximum speed of the light trains from 80 to 120 km. (50 to 75 miles) an hour when more than 5/6th of the vehicles are fitted with the continuous brake, to 105 km. (65.2 miles) when two thirds are, 95 km. (59 miles) when half are, and 80 km. (50 miles) when one third are. The maximum speed is still 15 km. (9.3 miles) on gradients of 1 in 83 and over.

The accelerated trains are made up of carriages of the 3 classes; 494 of them weigh less than 100 t. (98.4 Engl. tons) and the other 234 less than 150 (147.6 Engl. tons). They are made up as a rule of a composite 1st and 2nd-class carriage, these classes being little used (1) and a third-class coach, part of which has been made into a luggage van, which reduces the weight from 27 to only 15 tons, the 4-wheeled van being cut out. Unlike what has been done in Belgium, where the number of stops has been increased, on the *Nord* a certain number have been abolished and the stopping time limited to 30 seconds with 5 minutes at the junction stations, in spite of the suppression of the allowed margin for making good possible delays. The speed reduction to 30 km. (19 miles) an hour, when passing through points, has also been done away with, either by taking the accelerated train over the direct line, or by locking the points that were not previously.

A typical case to which Mr. Barret calls attention is that of the town of Beauvais, which is 68 km. (42.3 miles) from a main line and is served by trains coming from Amiens in 2 h. 24 m. with 24 stops, which account for 38 minutes in all (2), that is at an average speed of 27 km. (17 miles) an hour. The time taken for the journey has been reduced to 1 h. 34 m., the time spent in stops to 19 minutes, and the overall speed raised to 44 km. (27 miles) an hour.

The journey from Busigny to Hirson took 1 h. 42 m. with 27 minutes station stops; it now takes 1 h. 23 m. with 15 minutes station stops.

The time of the journey from Valenciennes has been reduced from 1 h. 37 m. to 1 h. 20 m. and the stopping time at stations from 26 to 18 minutes.

These accelerations have made it possible to gain about 25 % on the time taken for the journeys and advantage has been taken of the recasting of the timetables to improve the connections.

Obviously there was much to be done. In view of the deplorable services formerly found on the secondary lines, it was certain that the public would be only too glad to abandon the railway in favour of any other method of locomotion which, whatever it might be, could not but offer it advantages over the out-of-date services

(1) Over the whole of the System the frequentation of these classes, which is higher than on the secondary lines, is only 1 % and 5.7 %.

(2) This includes a 10-minute stop at Crèvecœur, to meet the regulation requiring all trains without lavatories to stop for 10 minutes once in each period of two hours.

offered by the railway. The *Nord* has taken a great step forward in speeding up its trains; it remains for it to offer its clients rolling stock which is clean, well lighted and comfortable, and running as smoothly as the buses. It is regrettable that the financial crisis and the transport crisis make it all so difficult, but this provision must be made if the effort made to complete the first step towards modernisation is not to be rendered sterile.

XIV-6. — **Light trains and railcars.** — The French railways, in their fight against road motor competition, have largely made use of trains of these two categories to replace accelerated local trains, fast trains and even express trains. From their very nature, such trains have always a limited number of places, and are sometimes of one class only (1st or 3rd), sometimes of two classes (1st and 2nd, or 1st and 3rd), and sometimes of all three classes.

TABLE 91.

A FEW EXAMPLES OF LIGHT TRAIN SERVICES (T. L.).

COMPANY AND RUN.	Trains and classes.	Distance		Time of departure.	Time spent.	Speed		Number of stops.
		Km.	Miles.			Km./h.	Miles/h.	
STATE.								
Argentan-Granville	Rap. (fast) I-II.	131	82.0	11.23 a. m.	1.46	64.7	40.2	4
Dol-Saint-Brieux	Expr. 3 cl.	91	56 5	11.24 a. m	1.41	54.4	33.8	3
Cherbourg-Saint-Brieux . . .	Rap. (fast) I-II.	271	168.4	4 00 p m.	4.35	59.2	36.8	9
Rennes-Dol-Dinard	Expr. 3 cl.	108	67.1	2.11 p. m.	1.56	55.9	34.6	3
Orbeq-Lisieux.	T. A. (railcar). II-III.	18	11.2	10.24 a. m.	0.36	30.0	18.6	7
ALSACE-LORRAINE.								
Strasbourg-Hagenau	T. U. L. (ultra light) II-III.	34	21.1	3.35 p. m.	0.38	53.7	33 4	7
Do. -Wissembourg . . .	Do.	68	42.3	11.04 a. m.	1 18	42.7	26.5	14
Do. -Sélestat	Do.	44	27.3	4.34 p. m.	0.49	53.9	33.5	9
Metz-Thionville	Do.	30	18.6	1.07 p. m.	0.35	51.4	31.9	7

The T.U.L. trains (ultra-light trains). — The *Alsace-Lorraine* Railways put into service during the 1933 Summer a series of trains known as « T.U.L. » trains similar to those which the Belgian railways have run for some years.

Whereas a T.U.L. runs in 1 h. 18 m., with 14 intermediate stops, from Strasbourg to Wissembourg, an express train, which only stops 3 times, only saves 9 minutes on this run. In the same way, a local train takes 61 minutes from Metz to Thionville, while a T.U.L. only takes 35 minutes though it stops the same number of times.

The accelerated trains of the *Est* Railway are composed, while waiting for them to be replaced by railcars, of rakes of three 2nd and 3rd-class carriages. Most of them cover without stopping a section of main line and then serve all the stations of a branch line. This is the case with the trains from Paris to Coulommiers, which are run fast to Gretz and

stop at all stations after that, and the trains from Paris to Château-Thierry which are run fast as far as Meaux and then become local trains. However, there are exceptions to this rule, and some of the accelerated trains also stop at intermediate stations between Paris and Meaux.

TABLE 92.

EST RAILWAY'S ACCELERATED LOCALS.

RUN.	Distance		Time of departure.	Time spent.	Speed		Number of stops.
	Km.	Miles.			Km./h.	Miles/h.	
Paris-Meaux and Château-Thierry. .	95	59.0	10.40 a. m.	1.25	66.3	41.2	7
-Paris to Meaux	45	28.0	10 10 a. m.	0.50	54 0	33.6	8
Do.	45	28.0	10.40 a. m.	0.34	78.2	48.6	—
Meaux to Château-Thierry . .	50	31.1	11.15 a. m.	0.50	60.0	37 3	6
Paris-Gretz and Coulommiers . . .	73	45.4	11.00 a. m.	1.20	54 8	34.1	9
Paris to Gretz	39	24.2	Do.	0.32	73 1	45 4	—
Gretz to Coulommiers	34	21.2	11.33 a. m.	0.57	35.8	22.2	8

XIV-7. — **Railcars.** — All the French Railways use railcars in some of their services, but these vehicles have received more advertisement on the *State* Railways as they are the only System using them for express services up to now. Two types are in use and others which will replace the express or accelerated services are undergoing inspection or under construction.

The BUGATTI petrol railcar, delivered in April 1933, has a power of $4 \times 200 =$ 800 H.P. and weighs 20 tons for a seating capacity of 52 passengers, with standing room for 24 (fig. 39). During its trials this vehicle reached a speed of 173 km. (107.5 miles) an hour; it is now is working the Paris-Dives and Houlgate fast express service via Trouville-Deauville, running from Paris to Trouville in one stage and then stopping several times beyond, at

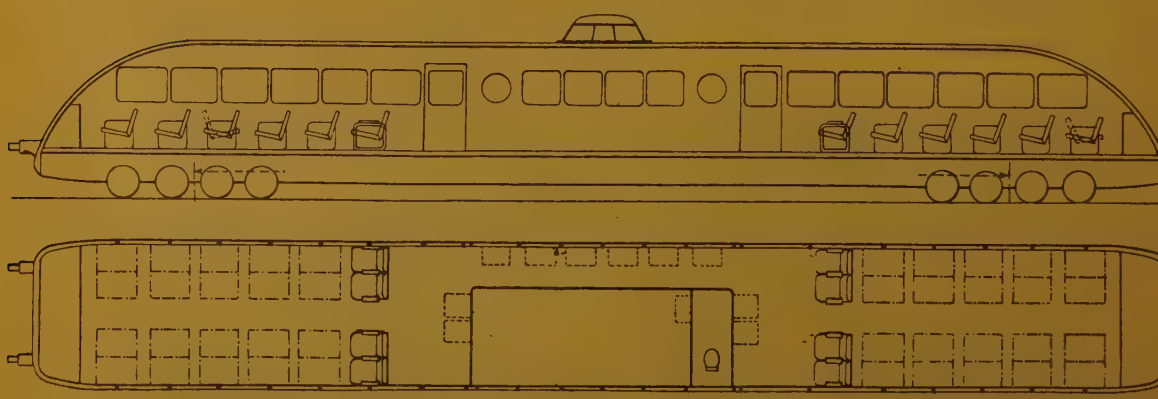


Fig. 39. — *Bugatti* fast railcar.
State Railways.

TABLE 93.

SOME RAILCAR RUNS.

COMPANY AND RUN.	Trains and classes.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	Stops.
STATE.								
ris St. L.-Deauville-Dives . .	Rap. (2) I.	244	151.6	1.50 p. m.	2.28	98.9	61.4	4 Bugatti.
Paris St. L.-Deauville . . .	Do.	221	137.3	1.50 p. m.	2.00	110.5	68.7	— Do.
Deauville-Dives	Do.	23	14.3	3.52 p. m.	0.26	54.0	33.6	3 Do.
ieux-Deauville	Local III.	30	18.6	6 21 a. m.	0.25	72.0	44.7	7 Renault.
Do.	Rap. III.	Do.	Id.	7.38 a. m.	0.20	90.0	55.9	1 Do.
Lisieux-Pont-l'Evêque. . . .	Do.	19	11.8	**Do.**	0.11	104.0	64.6	— Do.
Pont-l'Evêque-Deauville . . .	Do.	11	6.8	7.50 a. m.	0.08	82.5	51.3	— Do.
aen) Argentan-Alençon . . .	I-III.	43	26.7	9.06 a. m.	0.40	64.5	40.1	4 Micheline.
gentan-Granville	Rap. I-II.	131	81.4	11.23 a. m.	1.46	83.6	52.0	4 Do.
utances-Cherbourg	Do.	92	57.2	11.28 a. m.	1.31	60.7	37.7	1 (2').
blé-Châteaubriant	Rap. II.	97	60.3	9.51 p. m.	1.44	56.0	34.8	11
rdeaux Etat-Royan	Rap. 3 cl.	144	89.4	7.40 a. m.	2.05	69.1	42 9	
Bordeaux St. J.-Royan . . .	Do.	149	92.5	5.17 p. m.	2.02	73.3	45.6	1
Bordeaux Etat-Saujon . . .	Do.	140	87.0	**Do.**	1.49	77.0	47.8	
.vre-Fécamp (Dieppe)	Autosatos.	45	28.0	8.00 a. m.	1 29	30.4	18.8	
ouen) Duclair-Caudebec . . .	Do.	14	8.7	8.35 a. m.	0.30	28.0	17 3	3
son-Isigny-sur-Mer	Do.	14	8.7	9.20 a. m.	0.30	28 0	17.4	
PARIS-ORLEANS.								
erzon-Montluçon	T.A. (3) II.	126	88.3	10 17 p. m.	1.46	71.3	44.3	3 Micheline.
urs-Le Croisic.	T.A. Rap. II.	286	177.7	8.17 a m.	3.57	72.4	44.9	10
Tours-Saint-Nazaire . . .	Do.	257	159.7	Do.	3.15	79.1	49.2	4
ermont-Ferrand-Aurillac . . .		198	123.0	5.04 p. m.	3.06	63.9	39 7	
MIDI.								
rpignan-Arles-sur-Tech . . .	Auto St. dir.	49	30.4	8.37 a. m	1.07	43.9	27.3	3
Perpignan-Le Boulou	Do.	30	18.6	**Do.**	30	60.0	37.3	
ulouse-Auch	Do. Local.	89	55.3	9.29 a. m.	2.00 (1)	44.5	27.6	4
NORD.								
lle Madeleine-Haubourdin-Lille.	T. A. (3).	29	18.0	5.01 a. m.	0.57	30.5	18.9	D
eil-Beauvais	T. T. (4).	37	23.0	7.33 a. m.	0.33	67.3	41.8	3 cond. Mich.
auvais-Amiens (Summer). . .	T. T.	69	42.9	3.13 p. m.	1.09	60.0	37.3	3+3 cond. do.
lenciennes-Douai	T. T.	34	21.1	6.53 p. m.	0.30	68.0	42.3	1 Micheline.
EST.								
ul-Barisey-Mirecourt	III.	62	38 5	7.20 p. m.	1 26	43.4	26 9	20
recourt-Langres	Do.	98	60.9	5.00 a. m.	1.47	55.2	34.3	20
ngres-Poinson.	Do.	47	29.2	7.03 a. m.	0.52	53.1	33.0	9
ALSACE-LORRAINE (1).								
rasbourg-Hagenau	T.U.L. (5)	34	21.1	7.05 a. m.	0.35	58.3	36.2	6
Do. do. -Niederbronn.		56	34.8	12.06 noon.	0.53	63.4	39.3	6
Do. -Roeschwoog.		37	23.0	4.13 p. m.	0.35	63.4	39.3	8
Do. -Sélestat		53	32.9	6.53 a. m.	1.15	42.4	26.3	7

1) 1933-1934 Winter. — (2) Rap. = fast. — (3) T. A. = railcar or motor train. — (4) T. T. = light train.
) T.U.L. = ultra-light train.

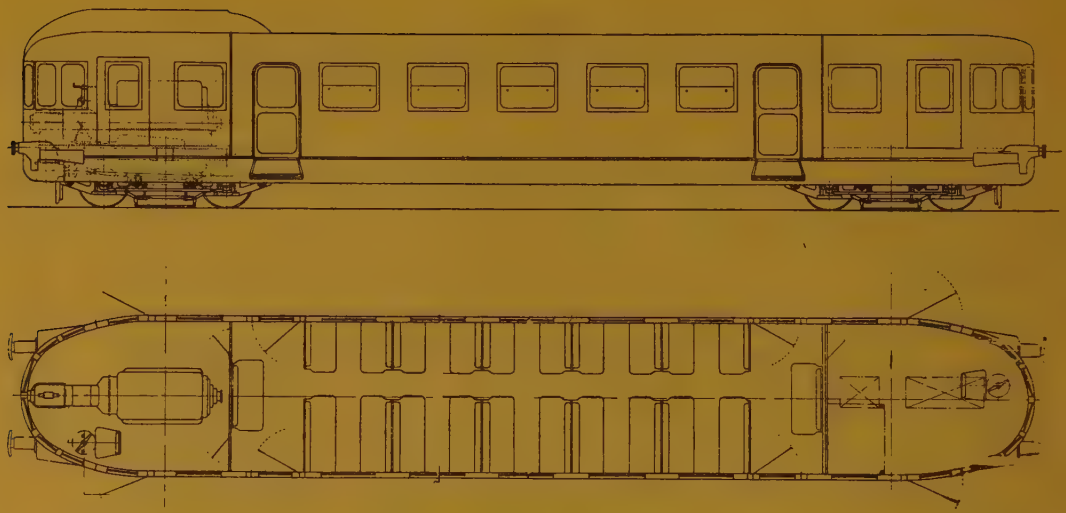


Fig. 40. — Fast *Renault* railcar.
State Railways.

Fig. 41. — *Renault* railcar.
Several railway systems.

the same time maintaining a very high speed between the stations.

Railcars are very expensive, and as they are still, it must be admitted, in the experimental stage, the Companies have no spares and are put to much inconvenience if anything happens to the railcars in service.

Profiting by the successful experiments carried out by the *Paris-Orleans* Railway to increase the power of its locomotives, the *State* Railways undertook a similar

experiment with some of their *Pacifics* and, on the 27th September last, put into service on the route served by the *Bugatti*'s a trial train made up of 5 coaches weighing 250 t. (246 Engl. tons). The journey was made in practically the same time as with the railcar, i. e. a little under two hours. The latent possibilities of locomotives transformed in this way are an important factor that must evidently be considered.

The FAST RENAULT RAILCAR carried on two bogies and driven by a 200-H.P. engine (fig. 40). — This unit weighs 22 t. (21.7 Engl. tons), with 56 seats and standing room for 10 passengers, and it is used on the hourly shuttle service between Lisieux and Trouville, usually with only

LINE.	Caen-Laval.	Cherbourg-St-Brieuc.	Chartres-Rouen.	Alençon-Sainte-Gauburge.
Distance. . . . . Km.	157	271	156	51
Miles.	97.6	188.3	96.9	31.7
Time spent	2 h. 51'	4 h. 30'	2 h. 22'	0 h. 44'
Overall speed . . . . . Km./h.	55	59	66	70
Miles/h.	34.2	36.7	41	43.5
Date service was opened	Jan. 1931	Oct. 1931	Oct. 1931	Oct. 1932
Time taken by steam train	5 h. 54'	9 h. 45'	—	—

one stop, at Pont-l'Evêque. Its speed is remarkable for such short distances. Certain all-stop journeys are as interesting as the above since they are made in 25 minutes, including 6 stops, i. e. at the average speed of 72 km. (44.7 miles) an hour. In this way 10 minutes are gained on the time taken by the light trains to cover the same distance.

Ten other four-wheeled RENAULT's with 80-H.P. Diesel engines are used on important cross-country routes (fig. 41).

Like the above these railcars gain an appreciable time on the light trains which they replace, only taking 40 minutes instead of the 51 required by the latter. They weigh 11 tons empty, and contain 76 first-class and 30 third-class seats. They are fitted with a Diesel motor giving 85 H.P. at 1 500 r.p.m.; the trailing axle is the driven one. There are four speeds forward and one reverse, so that it is possible to reach a working speed of 80 km. (50 miles) an hour, while a speed of 100 km. (62 miles) an hour was reached during the trials.

On the *Alsace-Lorraine* Railways a Renault car has been in service since September 1932. With a daily mileage of 400 km. (250 miles) it assures the services between Strasbourg and Haguenau and Niederbronn, and from Strasbourg to Sélestat via Barr and via Erstein. Below we give the leading dimensions, as well as those of the *Charentaise* and *de Dietrich* cars belonging to the same Company.

The first MICHELINE's with pneumatic tyres were used from the 1st March to the 18th September, 1932, between Mézières-Charleville and Givet (64 km = 39.8 miles) on the *Est* Railway. The ordinary

TABLE 94.

MAIN CHARACTERISTICS OF THE ALSACE-LORRAINE RAILWAYS' RAILCARS.

TYPE OF CAR.	Renault.	Charentaise.	de Dietrich.
Seats	60	60	75
Standing room for	10	10	15
Luggage . . . . . Kgr. (*lb.*).	1 000 (*2 200*)	1 000 (*2 200*)	1 000 (*2 200*)
Engine.	Diesel.	Diesel.	Diesel.
» power . . . . . H.P.	250	80	2 × 105
Maximum speed on the level. . . Km./h.	93	90	100
Miles/h.	57.8	56	62
Weight, empty . . . . . M. (*Engl.*) tons.	21 (*20.7*)	10.5 (*10.3*)	23 (*22.6*)

journey took 57 minutes instead of 1 h. 35 m. taken by the local trains, including 6 intermediate stops, 30 seconds being allowed for each stop.

From the 2nd October, 1932, these Micheline's took the place of local trains on the 42-km. (26.1 miles) section between Barisey-la-Côte and Mirecourt.

Time taken for the journey including 11 stops of 30 seconds each	54 minutes.
Time taken by local steam train.	1 h. 23 m.
Time taken by a mixed train . .	2 h. 38 m.

Since then, various Railway Systems (the *Paris-Orleans*, the *Nord* and the *State*) have put Micheline's into service. The last-named Administration has two types : some of them, in use since May, 1932, weigh 4.8 tons, have seats for 24 passengers and are fitted with a 95-H.P. Panhard motor. These work the Granville service, giving, beyond Argentan, an extension of the express service from Paris. With a mileage of 110 000 km. (68 350 miles) in one year there were only 24 punctures, the tyres lasting for 20 000 km. (12 425 miles) on the average.

A reversible 1933 type, still with 6 pairs of wheels, has 36 seats. These railcars which weigh 6.5 tons, have a 200-H.P. petrol motor with a maximum speed of 105 km. (65 miles) an hour.

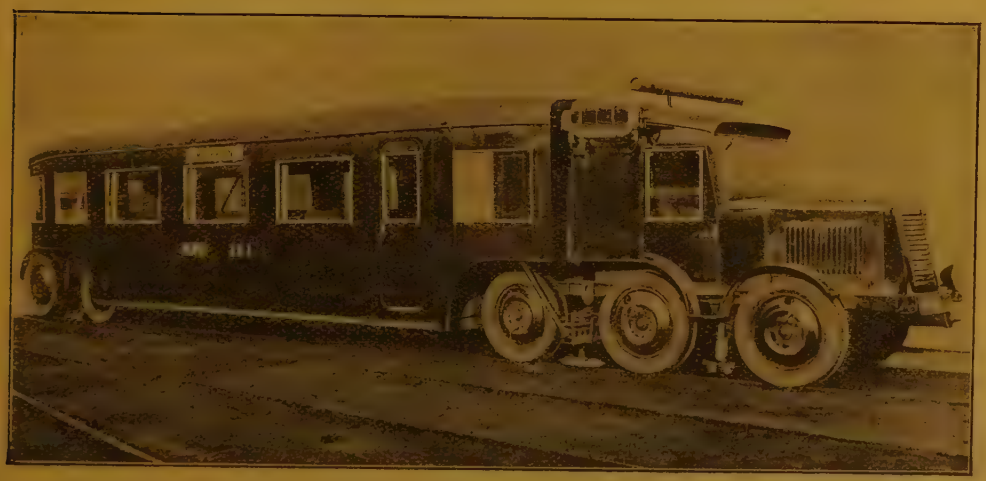
We show in figures 42 and 43 the Micheline put into service by the *Nord* Railway on the Creil-Beauvais line, as well as a larger Micheline (fig. 44).

The *Midi* system makes use of PAULINE's to serve some secondary lines. The « No. 2 Pauline's », in service since August, seat 55 passengers and have a luggage room with 10 m² (107 sq. feet) of useful floor space, and a driving compartment at each end. These vehicles, which only weigh 12 tons empty, are driven by a 80-H.P. Diesel engine, which enables them to reach on the level a speed of 60 km. (37 miles) an hour. They first ran on the Marmande to Mont-de-Marsan line where they covered 1 042 km.(645.5 miles) every day, instead of the 623 km. (385.5 miles) the steam trains used to run. According to the kind of train, the journey takes from 30 minutes to one hour less time; consequently this method of operation will be extended to the line between Mont-de-Marsan and Dax and Nérac and from Saint-Sever to Haguenau.

This reduction in the time taken for the journey also applies to other types of

Fig. 42.

Fig. 43.



Figs. 42 and 43. — Inside and outside view of *Micheline* railcar used on the Creil to Beauvais line.

vehicles. Thus the AUTOSATOS runs from Toulouse to Auch in only 2 hours, while the light trains take 2 h. 36 m. to 2 h. 44 m.

For some time this same railway has made use of the 4-wheeled CHARENTAISE railcars.

The *State* Railways have just taken de-

Fig. 44. — *Micheline* railcar.
Nord Railway.

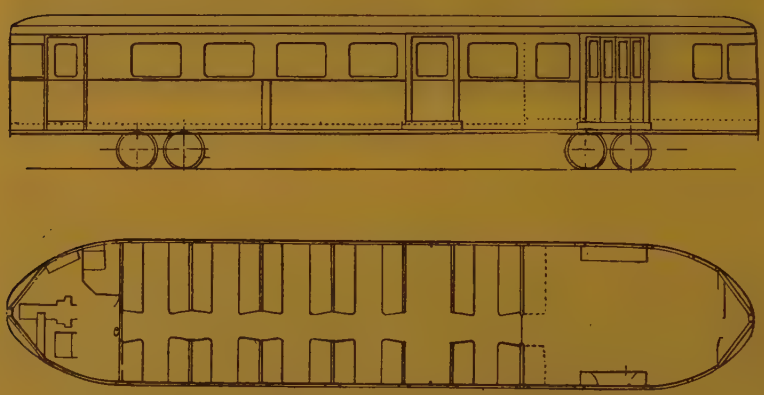


Fig. 45. — *Charentaise* railcar.
State Railways.

livery of larger Charentaise railcars (fig. 45) made of duralumin and aluminium, derived from the earlier type. These vehicles have four pairs of wheels grouped in twos, the two inner axles being driven by an 80-H.P. Diesel engine. They contain 55 seats and only weigh 10.5 tons empty. Their speed is 90 km. (56 miles) an hour on the level, 60 km. (38.3 miles) on gradients of 1 in 100 and 50 km. (31 miles) on gradients of 1 in 66.

Up to the present, only the *State* Railways use Autosatos in France. The service we have spoken about, between Duclair and Caudebec, is by road after Rouen.

All the trains of the Lison-Isigny-sur-Mer service are worked at the same speed, except one road motor car which takes 28 instead of 22 minutes.

The *P.L.M.* Railway has three types of railcars in service, two of which are high-

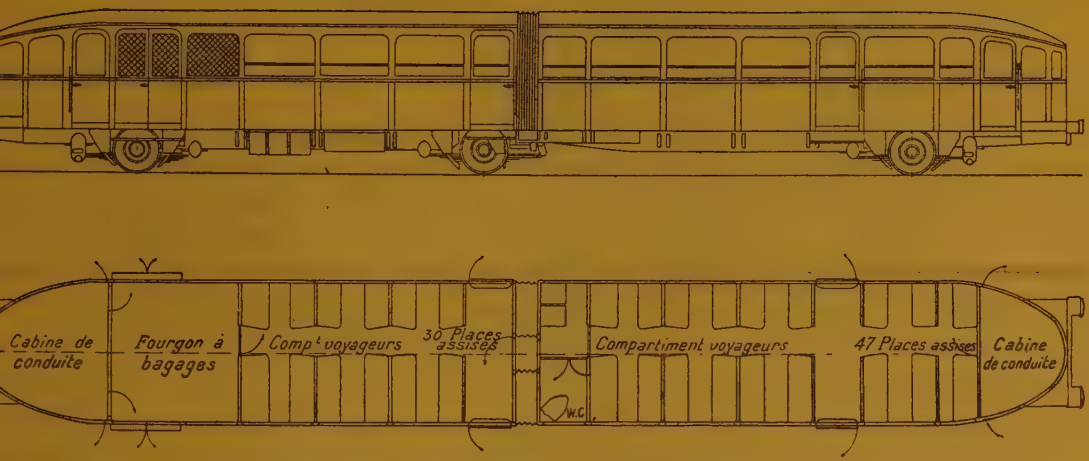


Fig. 46. — *Somua* railcar. — State Railways.

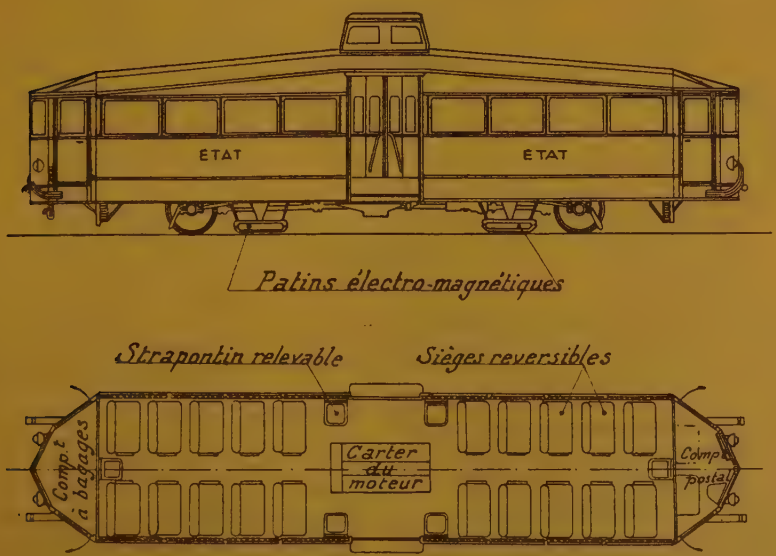


Fig. 47. — Railcar built by the « Compagnie Générale de Construction ». State Railways.

Explanation of French terms in figs. 46 and 47 :

Cabine de conduite = Driver's compartment. — **Fourgon à bagages** = Luggage compartment. — **Compt voyageurs** = Passengers compartment. — **Place assises** = Seats.

Patins électro-magnétiques = Electro-magnetic shoes. — **Strapontins relevables** = Tip-up seats. — **Sièges réversibles** = Seats with reversible backs. — **Compt à bagages** = Luggage compartment. — **Carter du moteur** = Engine housing. — **Compt postal** = Mail compartment.

speed bogie vehicles, and the third, a less powerful vehicle with two pairs of wheels. Below we give some characteristics of these vehicles, as well as their actual working speeds.

TABLE 95.

MAIN CHARACTERISTICS OF THE PARIS-LYONS-MEDITERRANEAN (P.L.M.) RAILCARS.

TYPE OF CAR. WHEELS.	Aciéries du Nord. Bogies.	Renault. Bogies.	4-weelhed.
Bogies, wheel base	2.88-2.05 m. *(9 ft. 5 25/64 in.—6 ft. 8 45/64 in.)*	2.20 m. *(7 ft. 2 5/8 in.).*	...
Distance between wheel centres.	14.20 m. *(46 ft. 7 in.).*	13.00 m. *(42 ft. 8 in.).*	...
Wheel base (4-wh. cars)	...	...	6.20 m. *20 ft. 4 in.).*
Driving wheels, diameter.	1.05 m. *(3 ft. 5 23/64 in.).*	0.85 m. *(2 ft. 9 12 in.).*	0.86 m. *(2 ft. 9 7/8 in.*
Carrying wheels, diameter	0.85 m. *(2 ft. 9 1/2 in.).*	0.85 m. *(2 ft. 9 12 in.).*	0.86 m. *(2 ft. 9 7/8 in.*
Number of passengers, seated	73	56	40
— — standing	20	10	10
— — total	93	66	50
Engine, type	Diesel.	Diesel.	Diesel.
— cylinders.	6 — 4-stroke.	12 — 4-stroke.	3 — 2-stroke.
— transmission	Mechanical.	Mechanical.	Mechanical.
— power. H.P.	170	200	80
— r.p.m.	900	1 400	1 500
Speeds Km./h. (*Miles/h.*).	16.0 *(9.9)*	20.4 *(12.7)*	20.0 *(12.4)*
— do.	25.5 *(15.8)*	36.2 *(22.5)*	32.0 *(19.9)*
— do.	54.4 *(33.8)*	61.4 *((38.2)*	50.0 *(31.0)*
— do.	88.0 *(54.7)*	100.0 *(62.1)*	...
Weight, empty . Met. (*Engl.*) tons.	...	24.5 *(24.1)*	11.3 *(11.1)*
— in working order . do.	42.8 *(42.1)*	31.3 *(30.8)*	16.3 *(16.0)*
— adhesive . . . . do.	26.7 *(26.3)*	17.2 *(16.9)*	8.2 *(8.0)*

XIV-8. — **Goods trains, mixed trains and suburban services.** — In table 96 we give some examples of goods trains (relating to the 1932/33 Winter).

The slow goods trains on the *Nord* Railway are grouped into three classes, and their average speeds are :

In the 1st class : from 30 to 33 km. (18 to 20.5 miles) an hour, with a maximum speed of 50 km. (31 miles) an hour;

2nd class : 40 km. (25 miles) an hour and up to 60 km. (37 miles) an hour;

3rd class : 50 km. (31 miles) and up to 75 km. (47 miles) an hour.

Thus the Lille-Paris train (No. 5002) weighing a thousand tons, runs as class 3. Some of these trains make relatively long non-stops runs, such as 146 km. (90 miles) from Longueau to Paris-La Chapelle, via Ormoy. This is covered every night by coal trains weighing 1 600 tons, coming from the Nord and Pas-de-Calais mines.

On the *Est* System many goods trains are

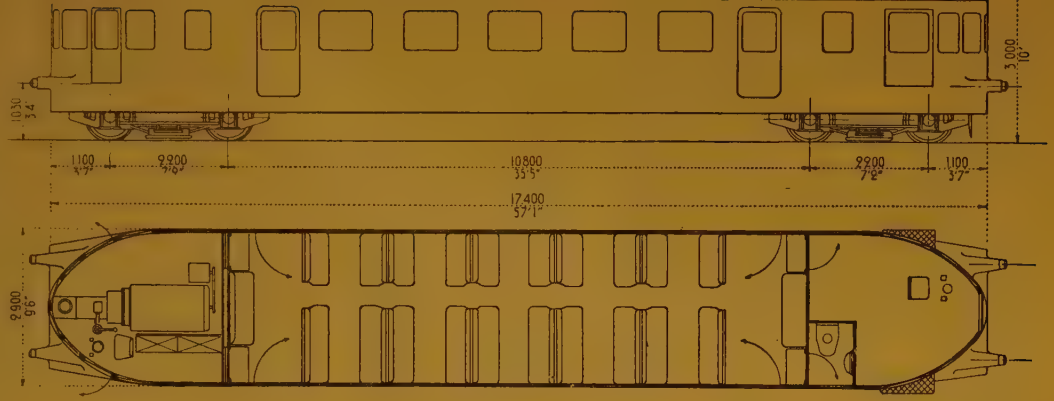


Fig. 48. — *Renault* railcar.
P. L. M. Railways.

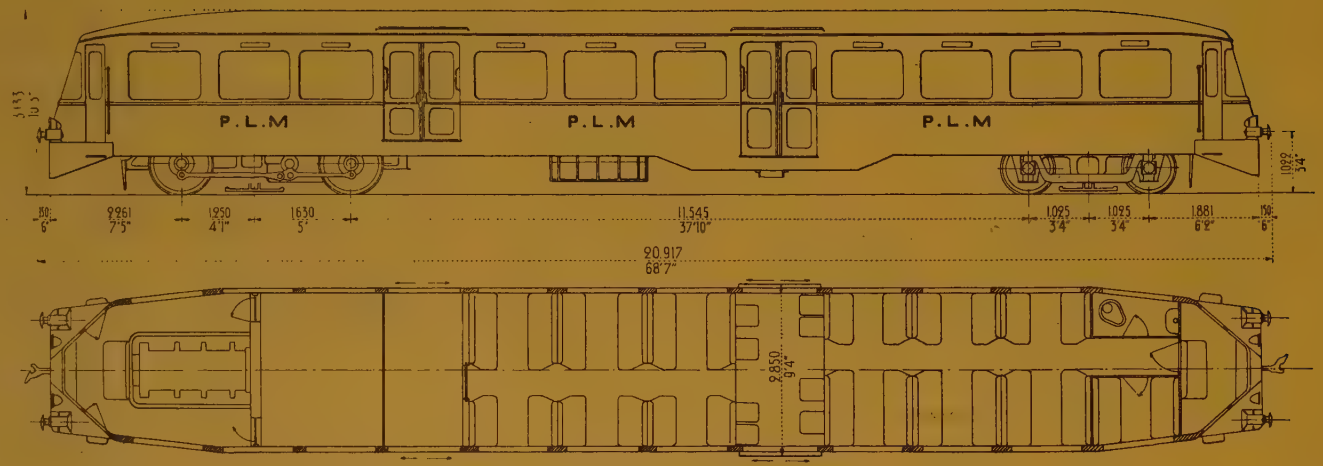


Fig. 49. — « Aciéries du Nord » railcar.
P. L. M. Railways.

TABLE 96.

TYPICAL GOODS TRAIN SPEEDS.

COMPANY.	RUN.	Distance		Time of departure.	Time spent.	Speed		Stops.
		Km.	Miles.			Km./h.	Miles/h.	
P.-O.	Paris-Ivry-Coutras.	526	326.8	10.45 p. m.	19.46	26.6	16.5	Through.
	Bordeaux B.-Paris-Ivry . . .	577	358.6	1.48 p. m.	19.42	29.0	18.0	
	Montauban-Brétigny	630	391.4	12.30 night	26.32	23.7	14.7	
	Juvisy-Chantenay	413	256.7	12.42 night	13.01	31.7	19.3	
Alsace.	Lutterbach-Colmar.	36.7	22.8		**0.57**	**38.8**	**24.1**	
	Metz-Réding	87	54.1		2.49	40.0	24.9	
State.	Batignolles-Havre	227	141.7	9.31 p. m.	6.30	35.1	21.7	Fast 8 stops
	Caen-Batignolles	238	153.9	10.00 p. m.	4.08	58.4	36.2	Do. 1 do.
	Brest-Vaugirard.	622	386.5	7.05 a. m.	15.39	39.8	24·7	Do. 20 do.
	Argentan-Vaugirard	196	121.8	10.41 p. m.	3.36	35.0	21.7	Do. 2 do.
	Sotteville-Havre.	94	58.4	2.47 p. m.	4.39	20.2	12.5	Slow 2 do.
	Rennes-Trappes	345	211.6	1.20 a. m.	8.46	59.3	36.9	Do. 6 do.

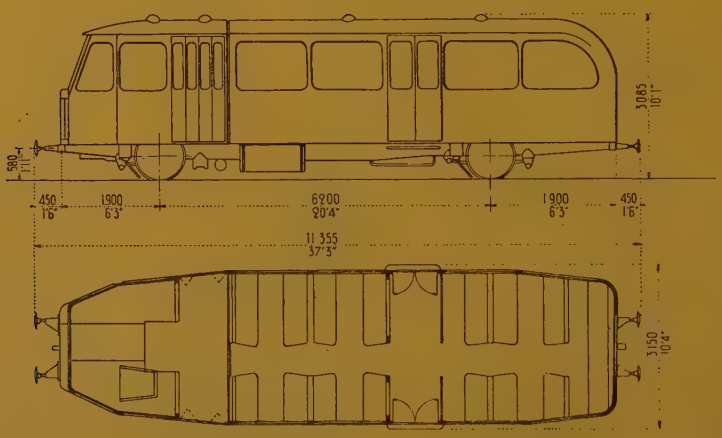


Fig. 50. — 4-wheeled railcar.
P.L.M. Railways.

timed at 50 km. (31 miles) an hour and trains fitted with continuous brakes may even reach this speed as their overall one. They often cover long stages without change of locomotive such as 205 km. (127 miles) from Châlons (marshalling yard) to Blainville (marshalling yard).

On lines with easy gradients, the *Midi* times its goods trains at 35 to 40 km. (22 to 25 miles) an hour with a tonnage of 1 000 to 1 200.

We are not surprised to see trains con-

TABLE 97.

A FEW EXAMPLES OF MIXED (M.V.) TRAINS.

COMPANY.	RUN.	Distance		Time of departure.	Time spent.	Speed.		Number of stops.
		Km.	Miles.			Km./h.	Miles/h.	
Midi.	Condom-Risele	76	47.2	12.54 noon	5.44	13.3	8.3	12 III. (Light tr. 2 h. 01).
Nord.	Le Tréport-Abbeville	38	23.6	10.51 a. m.	0.54	42.2	26.2	11
Est.	Sézannes-Coulom	60	37.3	6.30 p. m.	1.55	31.3	19 5	7
	MIXED TRAINS.							
A.-L.	Colmar-Mickolsheim Tr. . . .	23	14.3	8.44 a. m.	1.26	16.5	10.2	15
Midi.	Mont-de-Marsan-Gabarret . .	42	26.1	6.05 p. m.	1.43	24.5	15.2	9 (Local 1 h. 27'-M. V. 3 h. 13').
	Do. -Nérac	94	58.4	12.15 noon	6.14	15.1	9.4	17 (Local 3 h.34').
Est.	Igney-Cirey	18	11.2	7.15 a. m.	1.02	17.4	10.8	4

veying 2nd and 3rd-class or even only third-class carriages among the mixed trains. But it is more surprising to find, particularly on the *Est* Railway, between Toul and Saint-Vincent, Mirecourt and Chaumont, etc. trains with 1st and 3rd-class carriages as in England.

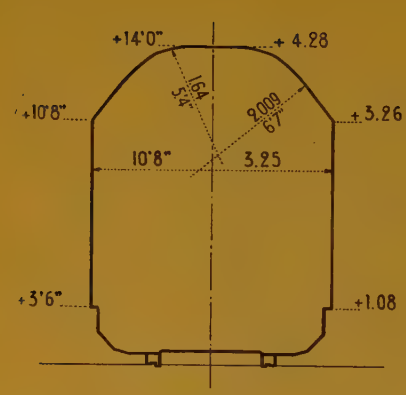
The speed of the Metropolitan trains is lower than that of the corresponding English trains. The reason is that the French Metro is worked on a different system, and that, in Paris, the stations are closer to each other than in London. This makes it possible to maintain a higher overall speed in London, where the running speed is, moreover, higher.

It is interesting to give, for Paris, comparative information about a typical tramway line and a road motor service (table 98). If the latter suffer from the road congestion, they are only meeting with the drawbacks inherent in surface lines.

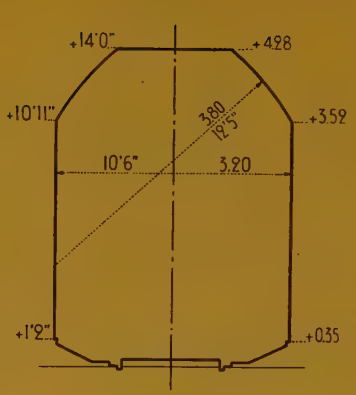
TABLE 98.

SOME URBAN RUNS.

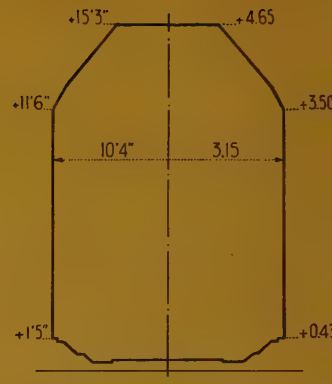
MEANS OF TRANSPORT.	Metropolitan Railway.	Motorbus.	Tramway.
Line	No. 1.	P^te^ Champerret.	No. 91
Run	Porte-Maillot-P^te^ Vincennes.	CA Gare Montparn.	Montparnasse-Bastille.
Distance . . . . . Km. (miles).	10.328 *(6.417)*	6.6 *(4.1)*	5.0 *(3.1)*
Total time taken . . . . . Min.	26	23	22
Number of intermediate stops	16	22	17
Average stopping time . . . . . Sec.	15	10	10
Maximum speed on the level . . Km./h. *(miles/h.)*.	50 *(31.0)*	40 *(24.9)*	40 *(24.9)*
Overall speed . . . . Km./h. *(miles/h.)*.	23.8 *(14.8)*	17.1 *(10.6)*	13.6 *(8.45)*
Minimum interval between trains . . Min.	1' 30"	5'	4'



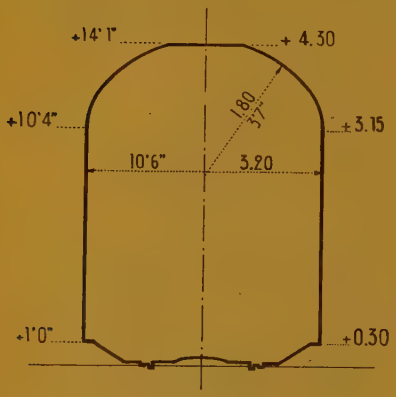
Nord.



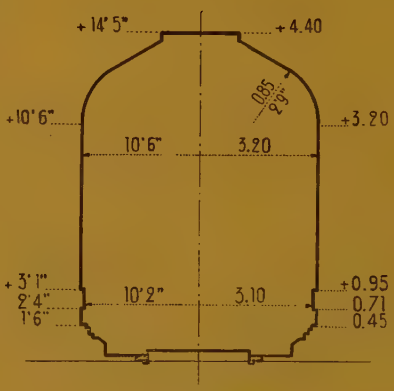
Est.



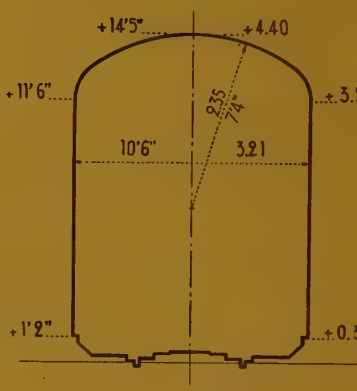
Alsace-Lorraine.



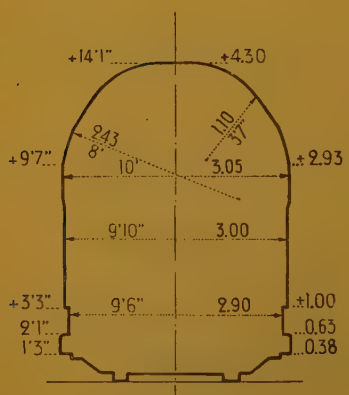
P.-L.-M.



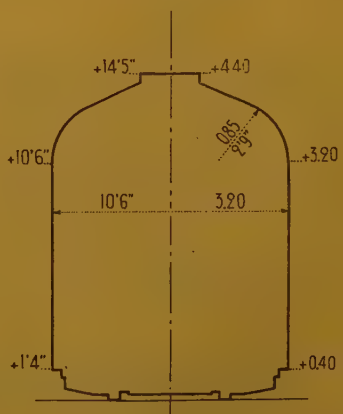
Paris-Orleans.



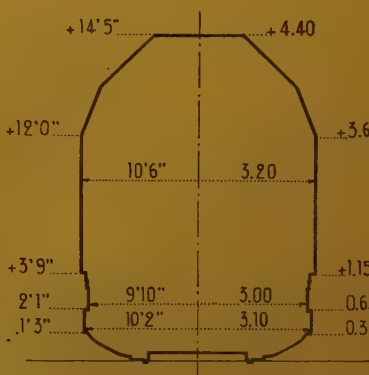
Midi.



Former Ouest.



Former State Rys.



Petite Ceinture.
(Inner Circle).

Fig. 51. — French railways' loading gauges.

CHAPTER XV.

Sleeping-car, saloon-car and restaurant-car services.

In order to give these vehicles the greatest possible comfort, the dimensions allowed by the loading gauge are made full use of, whilst of course taking into account the journeys the stock will have to make over other systems and even in foreign countries.

We have, therefore, collected the loading gauges of the different railways, and we give these at the beginning of the chapters devoted to the rolling stock of the Administrations concerned. In order to simplify the drawings we have, whenever possible, suppressed the unessential lines and have shown the metric measures on the right and the English measures on the left side.

Figure 51 shows the loading gauges of the 5 French main line Companies, of the *Alsace-Lorraine* Railways, and of the *State* Railways (distinguishing between the former *Ouest* and *State* constitutive systems), and finally the *Petite-Ceinture* Railway, which is used by a certain number of international trains.

Obviously we cannot give the modifications sometimes made necessary by local circumstances.

XV-1. — **The Companies' sleeping-car services.** — Under the various names of « lits-toilettes », « lits-salons » and « couchettes », the Companies have fitted up either complete coaches or, more often, a number of compartments in certain carriages, which they run over certain lines of their system and even over several neighbouring systems. These services are independent of those of the *International Sleeping Car Company*, and are even run on lines served by the latter and both kinds of vehicles are sometimes found in the same trains (fig. 52).

The *P.L.M.* Railway has particularly developed these services, and in a variety of ways which seems of greater interest technically than from the operating point of view (figs. 53, 54, and 55).

The « lits-salon » or « lits-toilette » are found in the following trains starting from Paris :

From Paris Mp. to Quimper, La Rochelle or Rochefort . . . . . *State.*
From Paris E. to Strasbourg, Epinal, Gerardmer and Sélestat . . *Est* and *Alsace-Lorraine.*
From Paris Aust. to Le Croisic and to Puigcerda (fig. 56) . . . . . *P.O.* and *Midi.*

And on the cross-country lines :

From Strasbourg to Port-Bou (*Alsace-Lorraine*, *P.L.M.* and *Midi*) and from Calais to Lyons (*Nord*, *Ceinture* and *P.L.M.*).

The use of « couchettes » compartments is more widespread.

We have given them all in figure 52, showing with a dotted line the routes covered by the interprovincial services, which are noteworthy. The names of the places where the services from Paris finally end are underlined.

All the railway systems, except the *Nord*, have « lits-toilette » services. The *P.L.M.* has modified these somewhat and called them « lits-salons » and the old « coupés-lits » have been taken out of service. As a rule all these vehicles, like those containing « couchettes » berths, only carry 1st-class passengers. On the *Est*, however, there are 1st and 2nd-class « couchettes », and on the *State* Railways there are « couchettes » for all three classes.

Fig. 52. — Sleeping-car services (« lits-salon » and « couchettes » compartment coaches) maintained by the railway companies.

The extra fare for these berths varies from one system to another, and the method of rating by zones and the kilometrage supplements are also in use.

On the *State* Railways there are only two rates for using the lits-toilette and lits-salon according to the distance, but these rates themselves are increased between the 1st May and 5th October every year.

Elsewhere the usual practice is to charge so much per kilometre wih a fixed minimum.

On the *State* Railways, a charge is

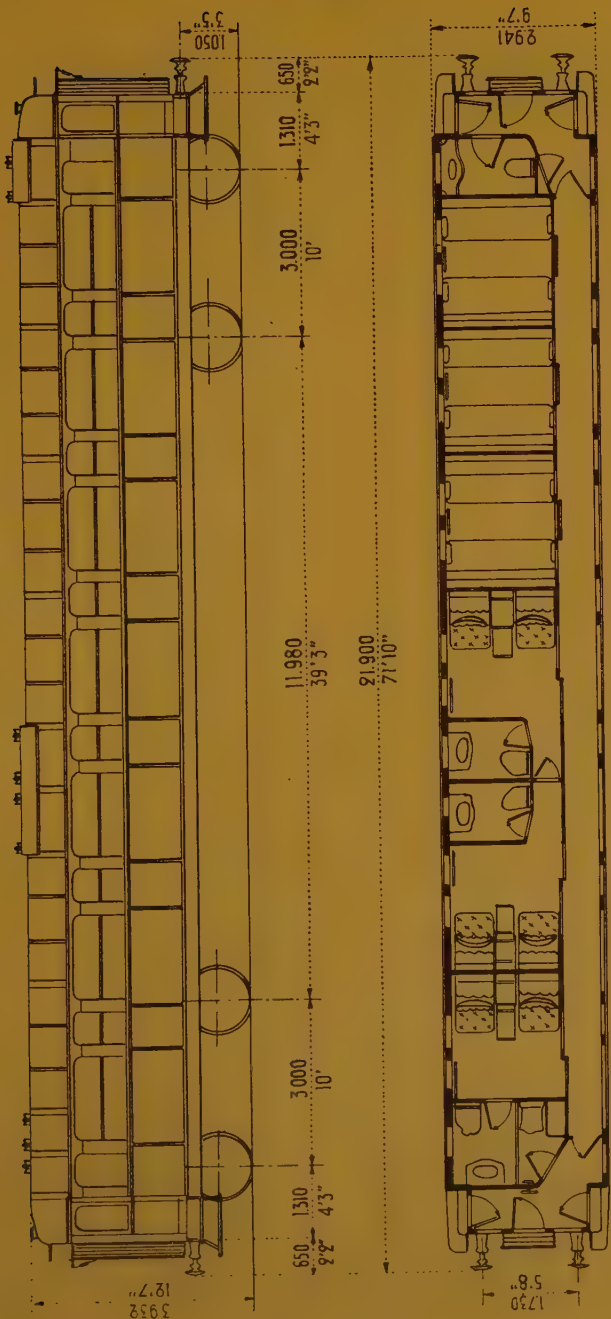


Fig. 53. — « Lits-salon » and « couchettes » cars.
P.-L.-M. Railway.

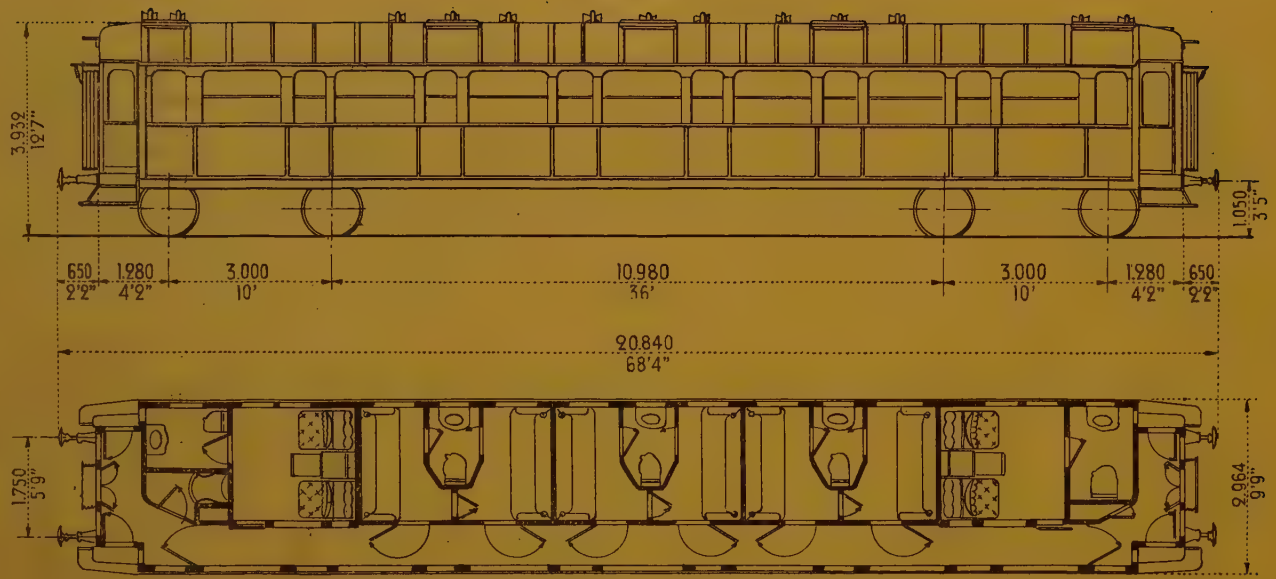


Fig. 54. — « Lits-salon » and « couchettes » cars.
P.-L.-M. Railways.

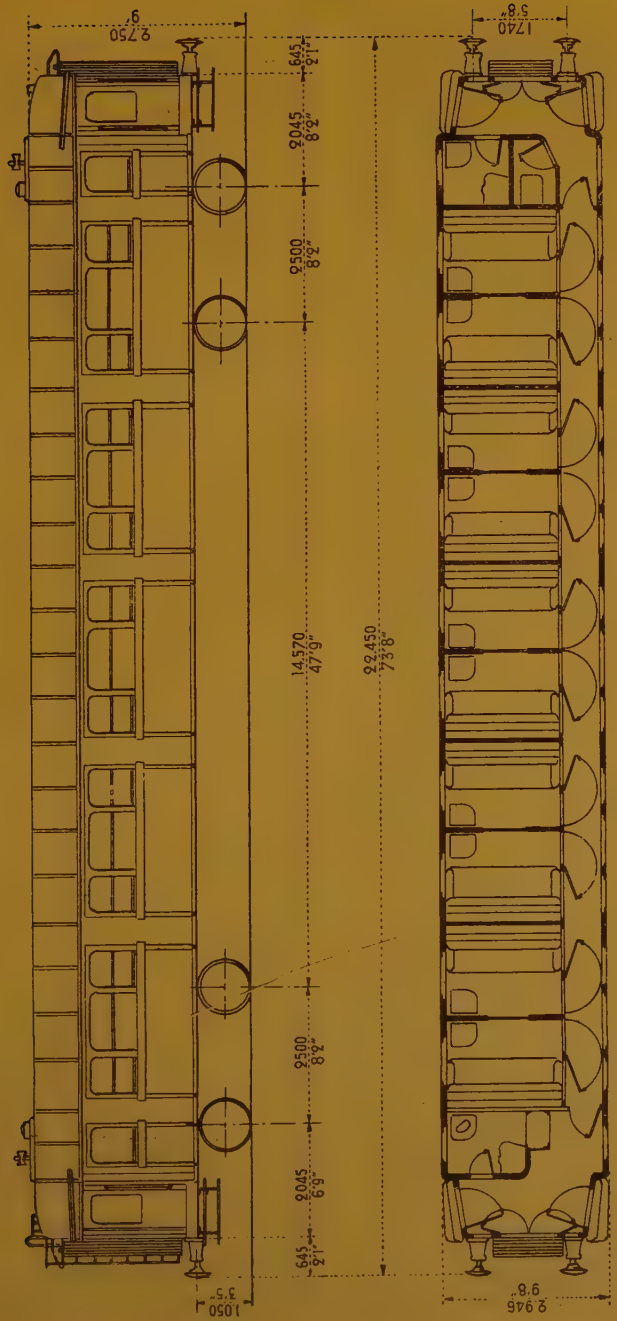


Fig. 55. — « Couchettes » car.
P.-L.-M. Railways.

made for the use of a sleeping berth according to the class (and this differs again in the Summer season), while on the *Est*, this supplement is 25 fr. a night, both in the 1st and 2nd-class cars. It is 45.05 fr. on the *Paris-Orleans*, where there are only 1st-class cars. On the *Midi* there is also a minimum rate (83.30 fr. or 99.95 fr. in the case of a sleeping car berth with sheets), and this sum is increased to 117.80 fr. in the case of passengers who board the train en route.

The *P.L.M.* is the Company with the greatest diversity of rates, as it has different rates applying to certain fast expresses (« rapides ») or to ordinary express trains.

The following are the different classes:

« *Couchettes* » *compartments*, « *rapides* » (fast expresses). — Fixed amount differing according to whether the distance is 500 km. (310 miles) or less;

« *Couchettes* » *compartments, express trains.* — Ditto.

Couchettes-toilette. — Same rates increased by 25 %;

« *Lits-salon* », *rapides.* — Fixed rates up to 350 km. (217.5 miles). Beyond this, kilometric rates with a maximum corresponding to a journey of 1 150 km. (715 miles);

« *Lits-salon* », *express trains.*— Same rates, but obviously different amounts.

1st-class sleeping cars, on « *rapides* », *or express trains.* — Same rates as in the case of « lits-salon ».

2nd-class sleeping car, « *rapides* » *or express trains.* — Two scales based on distance, each with a minimum and maximum amount, corresponding to journeys of less than 350 km. (218 miles) or more than 550 km. (342 miles).

3rd-class sleeping cars. — Three fixed amounts, corresponding to journeys of less than 700 km. (435 miles), or 700 to 950 km. (435 to 590 miles) or of more than 950 km.

This shows that there are nine different scales (ignoring those for the « lits-salon », as they are the same as for the 1st-class sleeping cars), and this means

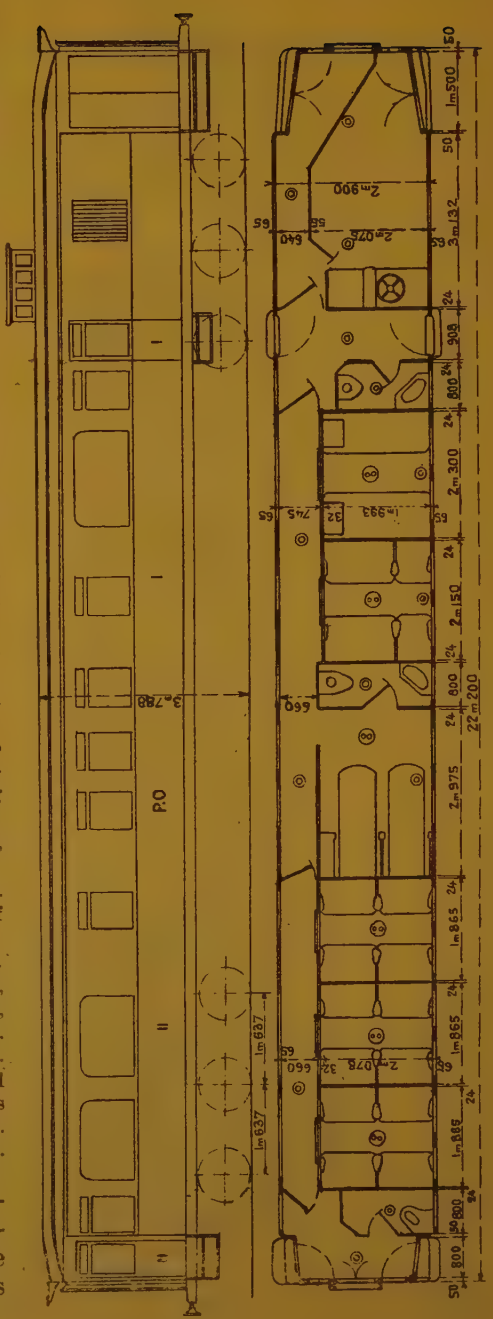


Fig. 56. — Composite 1st, 2nd-class and van carriages, including 1 « couchettes » and 3 « lits-toilette compartments ». Paris-Orleans Railways.

supplements varying from 50.90 fr. to 338.80 fr. for the Paris-Nice journey and from 34 to 156.10 fr. for the Paris-Lyons run, according to the class of vehicle used.

It is reasonable to charge different supplements according to the comfort offered the passenger, since the tare weight varies in consequence, but it seems that the railway might, without any great drawbacks, combine some of these rates in order to reduce their number.

In this connection, we may notice that the supplementary kilometric rate which is 0.2758 fr. for the 1st class on the « Simplon Express » is calculated to the eighth decimal part of a franc (0.19576875 fr.) in the case of the 2nd class. Luckily there are only two classes on this train !

XV-2. — **The Companies' restaurant car services.** — A good many years ago the former *Ouest Railway Company* introduced a travelling-bar service between Paris and Versailles. This idea has been taken up again recently in the form of buffet cars on several railways, and these complete the services worked by the *International Sleeping Car Co.* The vehicles in question were obtained by altering existing stock.

XV-3. — **International Sleeping Car Company's French services** (fig. 57). — As in the major part of the other Continental countries, most of the sleeping-car and restaurant-car services in France are worked by the *International Sleeping Car Co.*, which supplies the rolling stock and charges a supplement on the ordinary tickets. We will investigate this working in detail in the special chapter devoted to this Company, but here we give separately some information on the services arranged to suit the needs of each of the countries we consider.

On the French routes, most of the international « de luxe » trains are composed of rakes which, in the course of the journey, are sent to the different destinations, so these are usually heavy night trains. They are timed at slower speeds than the day-time expresses.

However, this is not the case with the Pullman trains, which include some of the fastest trains in the country, and which the Company has timed in connection with the London boat trains : the « Golden Arrow » (Calais-Paris), the Calais-Brussels and the Boulogne-Paris-Vichy; then, on the Riviera, the Milan-Cannes and, from Paris to San Remo, the « Côte d'Azur Rapide ». The other international day services are those from Brussels (« The Blue Bird », the « Etoile du Nord » and the « Edelweiss ») and the « Sud Express » on the French portion of its route in France. Two of these trains (the « Sud Express » and the « Côte d'Azur ») which formerly were made up of « de luxe » stock belonging to the railway companies (*Paris-Orleans* and *P.L.M.*) were afterwards converted into 2-class Pullman trains.

The stock on these trains has been much reduced in comparison with what it used to be a little time ago, and the « Sud Express », for example, now only consists of two bogie vans and three Pullman cars, one 2nd-class coach with 41 seats and two 1st-class cars with 24 and 18 seats respectively, the latter being a kitchen car. The total weight of this train is 211 t. (207.6 Engl. tons) empty, and 227 t. (223 Engl. tons) when fully loaded, and it is distributed as follows : 50 t. tare weight for each of the Pullman coaches without kitchen, 52 t. for that with kitchen, 27 and 32 t. for the vans. The length is 107 m. (351 feet).

Fig. 57. — Sleeping Car Company's « de luxe » train and sleeping-car services.

The various services are shown as follows :

Company's day services (Pullman cars) = Two thin parallel lines.

Night services = Heavy line.

Sections run over by both classes of train = A combination of the above.

Insolated sleeping car services = Thin continuous line, when starting from Paris; ----- in the case of provincial services.

Towns with through sleeping car services from Paris are underlined.

It is interesting to compare with the above the same particulars of the *Paris-Orleans* Rapide No. 15 as worked during the same period, and which is made up of 10 coaches weighing 401.5 t. (394 Engl. tons) empty, and 429.5 t. (423 Engl. tons) when loaded; this trains is made up as follows :

3 second-class coaches, 38 t. each;
2 first-class coaches, 42 t. each;
1 composite coach, 50.5 t.;
2 brake vans, 24.5 and 26 t.;
1 restaurant car belonging to the *International Sleeping Car Company* and weighing 52 t.

This train is divided up at Saint-Pierre-des-Corps, half of it going to Bordeaux and the other half to Saint-Nazaire.

Table 99 gives full particulars of the 18 trains belonging to the *International Sleeping Car Company* running in France.

One of these trains, the « Côte d'Azur Express » has been accelerated since the 8th October 1933 (cf. chapter XVI, § 4). It now appears likely that, upon completion of the electrification of a new section of the Paris-Bordeaux line, the same will be done for the « Sud Express » as from the 15th May 1934, though three stops in the course of the journey will be retained.

As we see, with only about 4 exceptions, all these trains start from Paris and are international trains, except the Calais-Paris boat trains (« The Golden Arrow ») and the trains serving the Riviera (« Méditerranée Express »), the Basque Coast (« Sud Express » over its French route) or the Pyrenees (« Pyrénées-Côte d'Argent Express »).

On the international transverse lines, there are two trains serving Brussels : the « Brussels-Calais Pullman » and the « Edelweiss » (from Basle and Switzerland). There is another train putting London into communication with Central Europe and the East, while certain services take to the Côte d'Azur passengers from foreign capitals.

In principle the *International Sleeping Car Company* covers the London traffic and likewise that of Paris; consequently some of its trains towards the eastern frontier are composed of two portions, one coming from Calais or Boulogne and the other starting from Paris.

In the case of the *Nord* System, the two portions join up at Liége (« Nord Express »). Formerly this took place at Jeumont, though by that route the journey was longer than it is by the present one.

As far as the *Est* system is concerned, the portions join up at Châlons-sur-Marne, in the case of trains via Strasbourg (« Orient Express »), and at Chaumont for the trains via Basle (« Arlberg-Orient Express ») and (« Engadine Express ») or via Delle (« Oberland Express »).

This latter train, which before the War came from Calais, was then a *P.L.M.* train. When the economic conditions changed, it was replaced by a rake which is coupled up to the « Arlberg-Orient Express » the service being assured by the *Est* Railway.

Similarly, the question is still under consideration of transferring the « Rome Express » from the *P.L.M.* Railway to the *Est* system, and sending it via Basle instead of via Modane, but this question, which depends upon international contingencies, has so far not been settled.

Even before the War, the *International Sleeping Car Co.* worked a certain number of day expresses composed of saloon cars and a restaurant car : the « Cabourg Express » shortly afterwards changed to « Trouville Express »; the « Vichy Express » with portions for Vichy and for Royan; the « Savoie Express » from Paris to Culoz, where it divided up into two

Table 99.

FRENCH RUNS OF THE INTERNATIONAL SLEEPING CAR CO.'S TRAINS.

RAILWAYS.	RUN.	Destination.	Distance		Time of departure.	Time spent.	Speed		NAME OF TRAIN.
			Km.	Miles.			Km./h.	Miles/h.	
Nord.	Paris N.-Calais Maritime.	(London).	299	185.8	12.00 noon	3.10	94.4	58.7	Golden Arrow.
	Saint-André-Calais Mar.	(Do.).	103	64.0	10.50 a. m.	1.07	92.2	57.3	Brussels-Calais, Pullman.
	Boulogne-Saint-André	Brussels.	142	88.2	5.35 p. m.	1.41	85.0	52.8	Do.
	Paris N.-Brussels M. (1)	Amsterdam.	311	193.2	11.25 a. m.	3.15	95.7	59.4	Etoile du Nord.
	Do. do. (1)	Antwerp.	Do.	Do.	6.10 p. m.	Do.	Do.	Do.	Blue Bird.
	Do. -Liége Guill. (1)	Berlin, etc.	367	228.1	6.15 p. m.	3.50	95.7	59.4	Nord Express (3).
A.-L.	Basle-Thionvile	Amsterdam.	332	206.3	9.20 a. m.	3.24	92.8	57.7	Edelweiss.
Est-A. L.	Paris E.-Châlons-s/M.-Strasbourg . .	Bucarest, etc.	503	312.6	7.55 p. m.	6.25	78.1	48.6	Orient-Express.
N.-E.-A. L.	Boulogne Mar.-Laon-Strasbourg . .	Do.	670	416.3	5.46 p. m.	8.34	78.2	48.6	Do. (Summer).
	Calais Mar.-Laon-Strasbourg. . . .	Do.	715	444.3	5.25 p. m.	8.55	81.1	50.4	Do. (Winter).
E.-A. L.	Paris-Chaumont-Basle	Do.	526	323.5	7.55 p. m.	5.35	94.2	58.5	Arlberg-Orient Express.
N.-E.-A. L.	Boulogne Mar.-Laon-Basle	Do.	736	454.1	5.46 p. m.	9.44	63.8	39.6	Do. (Summer).
	Calais Mar.-Laon-Basle	Do.	783	486.6	5.25 p. m.	10.12	76.8	47.7	Do. (Winter).
N.-E.-A. L.	Boulogne-Laon-Basle	Chur.	738	454.1	5.46 p. m.	9.44	75.8	47.1	Engadine Express.
	Do. do. -Delle	Interlaken.	676	416.7	Do.	11.51	56.9	35.3	Oberland Express.
	Basle-Laon-Calais Mar.	(London).	783	486.6	3.35 a. m.	11.50	66.2	41.2	Engadine Express.
N.-P.L.M.	Calais Mar.-Paris N.-PLM.-Valiorbe.	Istambul, etc.	777	478.9	R 2.25 a. m.	12.45	61.0	37.9	Simplon-Orient Express.
	Do. do. do. -Modane.	Rome, etc.	987	613.3	11.50 p. m.	15.35	63.3	39.3	Rome Express.
P.L.M.	Cannes-Ventimiglia	Milan.	66	41.0	1.21 p. m.	1.44	38.1	23.7	Milan- S. Remo-Cannes-Vent.
	Do. do.	Warsaw.	Do.	Do.	10.38 a. m.	1.33	42.6	26.5	Wien-S. Remo-Nizza-Cannes.
	Do. do.	Berlin.	Do.	Do.	12.55 p. m	1.35	34.7	21.5	Riviera Express (1).
N.-P.L.M.	Calais Mar.-Paris N.-PLM.-Vent. (2).	San Remo.	1437	892.9	2.30 a. m.	22.13	64.8	40.3	Calais-Méditerranée Express.
P.L.M.	Paris PLM.-Menton	—	1112	691.0	9.00 a. m.	14.11	78.4	48.7	Côte d'Azur.
N.-P.L.M.	Boulogne-Paris PLM-Mars. Arenc. .	(Bombay).	1128	700.9	6.12 p. m.	18.13	61.9	38.5	P. & O. Express (Summer).
	Calais-Paris PLM.-Marseille-Arenc .	(Do.).	1172	727.6	5.45 p. m.	18.40	62.7	38.9	Do. (Winter).
P.O.-M.	Paris P.-O.-Port Bou	Barcelona.	974	605.2	*7.20* p. m.	*12.06*	*80.5*	*50.0*	*Barcelone Express* (2) (3).
	Do. -Hendaye	Madrid, Lisbon	820	509.5	R 11.05 a. m.	9.40	89.0	55.3	Sud Express.
	Do. -Biarritz	—	799	496.1	R 11.26 a. m.	9.19	85.8	53.3	Do.
	Do. -Hendaye	—	820	509.5	8.40 p. m.	13.01	63.0	39.1	Pyrénées-Côte d'Arg. Exp. (3).
	Do. -Tarbes	—	835	518.8	R 10.14 p. m.	11.26	75.9	47.2	Do. (3).
	Do. -Pierrefitte	—	881	547.5	R 9.33 p. m.	12.17	71.7	44.5	Do. (3).

(1) Schedule in force as from December 1933.
(2) Present-day timings.
(3) The « Nord Express » (Paris-Liége), « Pyrénées-Côte-d'Argent Express », and « Barcelone Express », formerly made up exclusively of *Sleeping Car Company* stock, now also include coaches belonging to the railway systems.

TABLE 100.

INTERNATIONAL SLEEPING CAR CO.'S FRENCH DAY EXPRESSES
(ALL-SALOON OR ALL-PULLMANN TRAINS).
(Obsolete runs are shown in italics.)

NAME OF TRAIN.	RUN.	Distance Km.	Distance Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.
INTERNAL SERVICES.							
Cabourg Express.	Paris St. L.-Cabourg	244	151.6	*3.45* p. m.	*3.38*	*67.2*	*41.7*
Trouville Express	Do. -Houlgate	241	149.7	*Do.*	*3 47*	*63.7*	*39.5*
Deauville Express	Do. -Trouville-Deauville	221	137.3	*3.20* p. m.	*2.57*	*76.0*	*47.0*
Vichy Express	Paris Lyon-Vichy	365	226.8	*3 55* p. m.	*4.59*	*72.1*	*44.8*
Do.	Do. -Royat	426	261.7	*Do.*	*6.15*	*68.2*	*42.4*
Boulogne-Vichy Express	Boulogne-Paris-Vichy	635	394.6	1.00 p. m.	9.05	69.9	43.5
Savoie Express	Paris-Culoz-Bellegarde-Geneva.	614	381.4	*11.35* a. m.	*9.03*	*67.9*	*42.2*
Do.	Do. do. do. -Evian.	660	410.1	*Do.*	*9 54*	*66.7*	*41.4*
Do.	Do. do. -Chambéry.	574	356.7	*Do.*	*8.21*	*66.2*	*41.1*
Côte Basque Express	Calais-Paris-Biarritz.	1117	694.3	*3.00* p. m.	*16.59*	*65.7*	*40.8*
Do.	Do. -Irun.	1138	707.2	*Do.*	*16 51*	*72.9*	*45.3*
Do.	Do. -Pau.	1139	707.7	*Do.*	*17.25*	*65.5*	*40.7*
Côte-d'Azur Express.	Paris P.-L.-M.-Menton.	1112	691.0	8.15 a. m.	13.16	78.4	48.7
Sud Express	Paris Quai d'O.-Hendaye.	820	509.5	R 11 05 a. m.	9.40	89.0	55.3
Do.	Do. -Biarritz.	799	496.1	R 11.26 a. m	9.19	85.8	53.3
The Golden Arrow	Paris Nord-Calais	299	185.8	**12.00** noon.	**3.10**	**94.4**	**58.7**
FRANCO-BELGIAN SERVICES.							
Calais-Brussels Pullman	Calais-Brussels						
Etoile du Nord	Paris-Brussels-Amsterd.						
Blue Bird	Paris-Brussels-Antwerp.						
Suisse Express	*Ostend-Brussels-Basle*						
Edelweiss	Amsterd.-Bruss.-Zurich						
FRANCO-ITALIAN SERVICE.							
Cannes-Milan Express.	Cannes-S. Remo-Milan						

Sea chapter dealing with the International Sleeping Car Co.

portions, the one going to Chambéry, and the other splitting up again, and going to Geneva and Evian.

These services, which were suspended during the War, were afterwards restarted as Pullman trains, the first of them stopping at Trouville which had outrivalled the neighbouring seaside resorts.

The « Vichy Express » which has been run since 1925 had through coaches from Boulogne, so as to improve the English connections (1).

At the same time a whole series of train services with a single Pullman coach on the train were started :

On the *Nord*, from Paris to Calais, Boulogne and Liége;

(1) It took 1 h. 15 m. between arriving at Paris (Nord) and leaving Paris (Gare de Lyon).

On the *State*, from Paris to Dieppe, Deauville, and Dinard;

On the *Paris-Orleans*, from Paris to La Baule (and Le Croisic), and Bordeaux;

On the *P.L.M.*, from Paris to Marseilles and Geneva;

On the *Est*, from Paris to Vittel.

Most of these services have been suppressed at the present time, as well as the trains from Paris to Trouville-Deauville and to Vichy, and single Pullman coaches attached to the Companies' own express trains have taken their place. However, the two important day express trains of the *P.L.M.* and the *Paris-Orleans*, the « Côte d'Azur » and the « Sud Express » are formed entirely of Pullman stock.

In 1929, the *Sleeping Car Co.* introduced **all-sleeping-car trains**, and in France these ran between Paris and Marseilles (in Winter with an extension as far as Vintimille), and then between Paris and Vienna via the Arlberg.

It is well known that among the means resorted to by the railways to fight road motor competition, they have taken a more or less important interest in road services, so that they might be able to control the services offered by such companies. The *International Sleeping Car Co.* has done the same, and now runs « de luxe » road cars between Paris and Nice by the « Route bleue », by the Winter Alps route (via Grenoble) and by the Rhône Valley.

Sleeping-car services. — We have shown (fig. 57) nearly all the French sleeping-car services, except those which duplicate the « de luxe » trains; the trains which start from Paris are shown by a continuous fine line, and the provincial services by a dotted line. The underlined towns are where the sleeping-car services from Paris end.

Third-class sleeping-cars have already been introduced on three Systems: on the *P.L.M.* (from Paris to Nice and to Saint-Gervais-les-Bains), on the *Est* (from Paris to Belfort whence they go to Basle and Buchs, or to Delle and Interlaken), and finally on the *Alsace-Lorraine* (from Basle to Brussels). Such services will be extended to other lines, as the transformation of old 1st and 2nd-class carriages into 3rd-class sleeping cars proceeds.

Restaurant-cars. — These services are now completed by bar and buffet-car services.

The price charged for meals varies a little from one system to another.

On the « de luxe » trains, it is 7 fr. for breakfast and 30 fr. for lunch respectively, except on the « Bombay Express » whereon lunch costs 35 fr.

On the Pullman trains it is 9 and 40 fr. in the 1st class, 7 and 30 fr. in the 2nd class (except on the « Milan-Cannes » where the 1st-class price is 8 and 35 fr.) and 5 and 22 fr. in the restaurant cars on the other trains for breakfast and for lunch or dinner respectively, this latter price being increased to 25 fr. on a certain number of express trains of each System.

XV-4. — **The trans-Capital services** (fig. 58). — Crossing large towns is always difficult and the problem has been solved in various ways in the different countries in accordance with the local requirements. For this reason it is always interesting to investigate this matter in detail.

In London, the trains passing from one railway system to another completely avoid the capital, with the single exception of the « Sunshine Express » which passes through the suburbs. The position is quite different in Paris where the railway lines spread out like a fan from

MILEAGES OF INTER-COMPANY LINES OVER WHICH THE INTERNATIONAL SLEEPING CAR CO'S TRAINS ARE RUN

(Fig. 58.)

(Trains which are now obsolete or run over another route are shown in italics.)

RAILWAYS.	LINES.	Via.	Km.	Miles.	TRAIN.
Nord-Est.	Amiens-Châlons-sur-Marne	Laon.	217	134.9	Orient Express. Carlsbad Express.
Do.	Do. do. -Chaumont	Do.	351	218.1	Arlberg-Orient (Summer). Engadine-Oberland (Summer).
Do.	Paris Nord-Paris Est	Inner Circle.	6.0	3.7	Arlberg-Orient (Winter). Engadine-Oberland (Winter).
Do.	Paris Nord-Ivry	Do.	13.4	9 0	—
Do.	La Chapelle Charbons-Gagny (1) . . .	Do.	11.6	7.2	*Prague-Warsaw* (8). *Simplon-Express* (8).
Nord-P.-L.-M.	Paris Nord-Paris P.-L.-M. (2)	Do.	14.6	9.1	Rom Express. Méditerranée Express. Simplon-Orient Express.
Do.	La Chapelle-Bercy-Paris P.-L.-M. (2) (3).	Do.	11.6(9)	7.2	*Oberland Express.* *Calais-Méditerranée.* *Simplon-Orient.*
Do.	Pierrefitte-Villeneuve (4)	Outer Circle.	34.5	21.4	Bombay (P.-O.) Express. Lloyd Express (not Sl. Car. Co.) *P. & O. Express.*
Nord-P.-O.	Paris N.-Paris Quai d'Orsay.	Inner Circle.	19.1	11.9	*Côte Basque Express* (7).
Nord-Belgian Rys. Do.	Boulogne Mar.-Baisieux (5) (6). . . . Calais Mar.-Baisieux (6).	Saint-André. Do.	152.6	94.8	Calais-Brussels Pullman and Nord Express.
Nord-Nord Belge.	Calais Mar.-Jeumont	Lille.	211.0	131.1	*Nord Express.*

(1) La Chapelle is 48.7 km. (30.3 miles) from Creil, and 1.6 km. (1 mile) from Paris N.

(2) The Nord and P.L.M. Railways are connected at Bercy, which is at 3 km. (1.9 miles) from Paris (Gare de Lyon).

(3) Distance, over this line, between Calais Mar. and Paris P.L.M.: 308 km. (191 miles), and between Creil and Paris P.L.M.: 60.3 km. (37.5 miles).

(4) Distance, over this line, between Calais-Mar. and Lyons : 832 km. (515.9 miles).

(5) No stop in Calais. The distance between the harbour station and the town station is 3 km. (1.9 miles) ; that between Boulogne Mar. (harbour) and Boulogne-Ville (town) is 1 km. (0.6 mile).

(6) Does not enter the Lille terminal station. The distance between St-André and Lille is 7 km. (4.4 miles), and between St-André and Baisieux, 10.6 km. (7 miles).

(7) Before the War. — (8) For a few years after the Armistice. — (9) According to the P.L.M. timetable.

Fig. 58. — Paris suburban lines, over which cross- or trans-Capital services are worked.

each of the terminal stations and only link up by means of the two Ceinture Railways. With the exception of goods trains, a couple of trains which are extended from Paris-Nord to Paris-P.L.M., and one express train (the « Lloyd Express ») which only runs every three weeks, only trains belonging to the *International Sleeping Car Company* fall into the class of train we are dealing with here.

We have pointed out that this Company deals with an important English passenger traffic, to be added to that to or from Paris. These passengers do not want to stop in Paris, but the requirements of the service will make such a stop necessary when the total number of such passengers will be insufficient. Two alternative solution immediately present themselves.

When the traffic is heavy, the English passengers going towards the Eastern frontier of France are sent directly from Calais or Boulogne to Châlons-sur-Marne or Chaumont, were the train links up

with those from Paris. At other times, they will travel via Paris, in a through portion of the train which goes from Paris-Nord to Paris-Est over the Petite Ceinture, in order to link up with the French trains. This route is longer, but is less costly for the Company.

However, this at once raises another problem : should these trains from Calais or Boulogne run into one or two of the Paris termini ?

When only a part of the train from Calais or Boulogne continues its journey beyond Paris, the problem does not arise; this is the case with which we are dealing, in which two terminal stations must of necessity be used.

But other trains, such as the « Simplon-Orient Express » or the « Calais-Méditerranée Express » continue the journey without dropping any carriages en route like the preceding trains. The passengers passing through Paris do not care whether the train goes to one, two or even to no terminal station; all they want is to save as much time as possible. The passenger who is using these trains to get to Paris does not care very much either what terminal station he arrives at: as far as he is concerned one station is enough as he would lose too much time if he remained in the train until its arrival at the second terminus. There remains the case of passengers who have to change in Paris for some other destination, for some of whom the second terminus may be more convenient than the first. The question therefore depends upon the passengers carried.

Finally there are the boat trains : the « P. and O. Express » of the *Peninsular and Oriental Company* (Calais-Paris-Marseilles-Arenc) and the « Lloyd express » of the *Rotterdamsche Lloyd* (The Hague-Paris-Marseilles La Joliette), in which trains the majoritiy of passengers pass through Paris, where very few additional passengers are picked up. In this case it is obviously sufficient to run into a single terminus and even, if the number of foreign passengers is sufficient, to avoid Paris altogether by means of the Grande Ceinture.

We have found it very difficult to get the actual lengths of the different inter-railway connecting and by-pass lines; we think therefore it will be useful to give these figures here, in table 101 and figure 58, adding the description of each of the trains running over them.

The distances from Paris to the different stations of Marseilles, where the Company's trains terminate are as follows :

Paris-Marseilles Saint-Charles, 863 km. (536.2 miles), « Côte d'Azur Pullman Express ».

Paris-Marseilles Arenc, 858 km. (533.2 miles) « Calais-Méditerranée Express ».

Paris-Marseilles La Joliette, 860 km. (534 miles), « Bombay (P. and O.) Express » and « Lloyd Express ».

(To be continued.)

* * *

ERRATUM.

January 1934 issue, page $\frac{73}{129}$, Table 71.

		Miles.	Km.
Willesden Jn.-Coventry (Birm.) run (L.M.S.R.)	*Instead of*	91	142.4
	Read	88 3/4	142.8

Opposite this run, delete : « Cheltenham Flier » in the last column, as this train does not run over the L.M.S.R., but over the G. W.'s lines.

Page 85/141, first column : Delete 2nd paragraph, *i. e.* from « But apart..... *to*..... Cheltenham Flier's ».

[624. (0 & 669)]

Aluminum enters bridge construction at Pittsburgh,

by CHARLES M. REPPERT,
Chief Engineer, Department of Public Works, Pittsburgh, Pa.

(From *Engineering-News-Record.*)

Historic Smithfield Street Bridge in Pittsburgh has been reconstructed for longer life by removing its old steel and timber floor and placing a new floor of high-strength aluminum alloy.

* * *

First application of aluminum to bridge construction has just been accomplished at Pittsburgh, Pa., where the Smithfield St. Bridge, principal crossing of the Monongahela River since its construction in 1882, has been reconstructed by building a new floor of high-strength aluminum alloy in place of the old steel and timber floor. The purpose of the reconstruction was primarily to lighten the dead load, in order to make it possible to continue the bridge in service safely.

In this work the entire floor system of the bridge was reconstructed using aluminum alloy members designed and built quite like steel members. No unusual conditions were encountered in either design, fabrication or erection, and the construction procedure throughout was quite closely the same as followed in comparable steel work. The heavy timber floor of the old roadway was replaced with a battledeck type of floor constructed wholly of aluminum and topped with an asphaltic surfacing. This deck slab, whose design was developed by the Aluminum Company of America and checked by extended service tests, weighs together with the asphaltic surfacing, only 30 lb. per sq. foot.

The Smithfield St. Bridge has been a continuing problem for many years. Its age of 51 years combined with the fact that it has been carrying heavier loads than intended, on both the streetcar and the vehicle roadways, led eight or ten years ago to recommendations for the replacement of the entire structure. It was then thought that while the bridge could be maintained for a few years, its early replacement was inevitable, and in consequence all except the most necessary maintenance work was discontinued. At the same time the wooden floor was not only a large item of maintenance expense but furnished an unsatisfactory roadway surface and constituted a fire hazard.

Replacement of the bridge by a new structure was considered essential at that time also because the bridge was inadequate for traffic und was expected to become even more inadequate as time went on. Subsequently, however, the building of the new Liberty Bridge and Tunnel route and the modernization of the Point Bridge and the South Tenth St. Bridge (respectively below and above the Smithfield St. Bridge) rendered the structure less important to through traffic. Smithfield St. Bridge thus tended increasingly to become a local facility in respect to vehicular traffic, although as a street-railway bridge it still maintained the position of being an essential link in the city's transportation system.

Under these circumstances, some strengthening of the trusses of the bridge was carried out in 1928, and last year a careful restudy of the whole situation was carried out with a view to developing a plan by which the dead load on

the bridge could be reduced and the structure thereby safely continued in service. The desired improvement was also intended to provide a better roadway surface, decrease maintenance expense and remove the ever-present fire hazard.

After various preliminary designs had

Fig. 1. — By taking some 700 tons of dead weight from the load carried by its trusses, the old Smithfield St. Bridge in Pittsburgh, considered obsolete, was made capable of serving traffic for many years to come. The inherent lightness of aluminum and saving in deck weight through a novel ribbed slab of metal were prime factors in weight reduction.

been developed, the possibility that structural aluminum alloy might offer a solution was taken up, and it was found that through this material not only could the overstressing of the trusses be relieved but a permanent hard-surfaced roadway floor could be provided that would assure satisfactory service of the structure for many years. From the economic standpoint, deferring the replacement of the structure over a period of years would still mean a large net saving to the city after taking into account the cost of the floor reconstruction. On this showing it was decided to adopt an all-aluminum floor system.

The old structure.

The Smithfield St. Bridge spans the Monongahela River in a north-south direction at a strategic central location in downtown Pittsburgh. The present structure, designed by Gustav Lindenthal and erected in 1882, replaces the first suspension road Bridge of John A. Roebling. It is the third bridge across the river at this point — the first, a covered wooden bridge, having been built more than 100 years ago. Mr. Lindenthal's own description of the bridge (« Rebuilding of the Monongahela Bridge at Pittsburgh », *Transactions*, American Society of Civil Engineers, 1883, pp. 353-392) may be consulted for detail, but in general the present bridge as built consisted of two identical spans, each 360 feet long, of two Pauli or double elliptical trusses spaced 25 ft. 8 in. on centres, carrying a roadway suspended below the trusses by pin-connected hangers. Both steel and wrought iron were used in the construction of the bridge, the use of steel at that time being a distinct innovation.

A third truss was added to each span in 1890, 20 ft. 8 in. upstream from the existing bridge, to provide a second roadway; the piers had been built long enough at the time of original construction to provide for the addition. At first one street-car track was placed on each side of the middle truss, but in 1911 the new (upstream or east) truss was moved 4 1/2 feet farther upstream, widening the second roadway to 24 ft. 8 in. between truss centers, so that both street-car tracks could be placed on the east roadway and the west roadway kept free for highway traffic. At that time also (1911) the present floor system was installed under the street-car tracks, while the floor system of the west or downstream roadway remained the same as in 1882 except for repairs and occasional replacements.

Briefly, the highway floor system consisted of wrought-iron plate-girder floor beams and six longitudinal stringers, supporting a laminated timber floor 11 inches thick, surfaced with two rows of steel traffic plates on each of the two traffic lanes. The floor system of the east roadway consisted of floor beams and four lines of stringers, and the track ties rested directly on the stringers. Sidewalks, bracketed out on both sides of the bridge, were floored with a single layer of 2-inch plank.

Reinforcement to reduce high stresses.

A careful analysis of the stresses in the bridge was made in 1926; it showed that the east and center trusses were stressed to a point regarded as excessive, considering the age of the bridge. In 1928, therefore, additional steel bars were welded to the face of the outside eyebars of the upstream and center trusses, with the effect of reducing the live-load stresses somewhat, though having no appreciable effect on dead-load stresses.

Examination of the bridge in 1932 revealed the necessity for numerous repairs to the main stringers, trusses and floor system, including renewal of the wooden floor and the repair or replacement of the street-railway stringers. Because of the magnitude of the necessary repairs and the increasing fire hazard in the wooden floor, a study of alternative types of floor was undertaken. Concurrently there was developed the idea of reducing the dead load on the structure in order to decrease the stresses in the main members of the trusses and thereby prolong the useful life of the structure. Although the bridge was then 50 years old, it did not seem to have deteriorated unduly in its essential structure.

In this situation, attention was directed to a comparatively new material, structural aluminum alloy. Structural shapes and plates of this material had been used in railway cars, trucks and buses, dirigibles and airplanes, overhead traveling cranes and dragline booms for

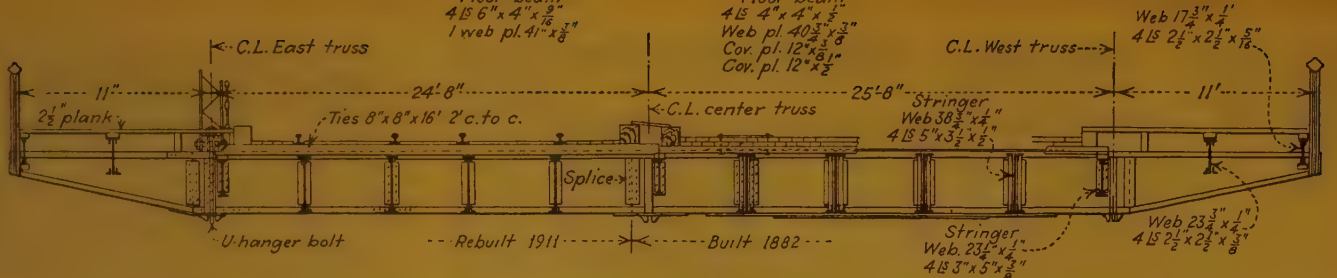


Fig. 2. — Old wrought-iron and steel floor, with 11-inch timber decking for vehicle roadway.

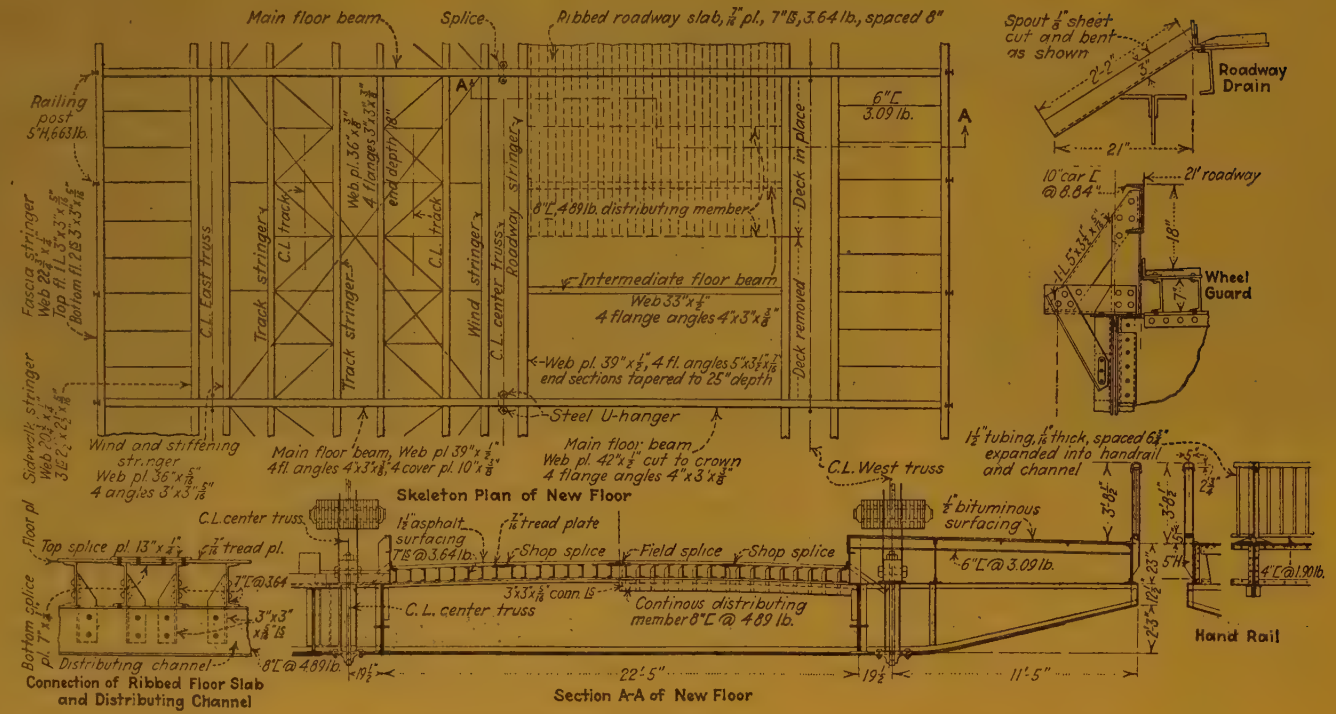

Main floor beam
Splice
Ribbed roadway slab, 7/16" pl., 7"I, 3.64 lb., spaced 8"
Railing post 5"H, 6.63 lb.
Fascia stringer
Sidewalk stringer
Wind and stiffening stringer
C.L. East truss
Track stringer
C.L. track
Roadway stringer
Wind stringer
C.L. center truss
Deck in place
6"I 3.09 lb.
8"I, 4.89 lb. distributing member
Intermediate floor beam
Web 33"x1/4"
4 flange angles 4"x3"x5/8"
Web pl. 39"x1/2", 4 fl. angles 5"x3½"x7/16" end sections tapered to 25" depth
Deck removed
Steel U-hanger
Main floor beam, Web pl 39"x1/2", 4 fl. angles 4"x3"x7/16", 4 cover pl. 10"x5/16"
Main floor beam Web pl. 42"x1/2" cut to crown 4 flange angles 4"x3"x5/8"
C.L. West truss
Skeleton Plan of New Floor
Spout 1/8" sheet cut and bent as shown
Roadway Drain
21"
10" car I @ 8.84"
21' roadway
Wheel Guard
1½" tubing, 1/16" thick, spaced 6½" expanded into handrail and channel
Hand Rail
C.L. center truss
1½" asphalt surfacing 7"I @ 3.64 lb.
7/16" tread plate
Shop splice
Field splice
Shop splice
½" bituminous surfacing
6"I @ 3.09 lb.
Top splice pl. 13"x1/2"
7/16" tread pl.
7"I @ 3.64
3"x3"x5/16" ∠s
3"x3"x5/16" conn ∠s
C.L. center truss
Continous distributing member 8"I @ 4.89 lb.
Bottom splice pl. 7"x1/2"
Distributing channel
8"I @ 4.89 lb.
Connection of Ribbed Floor Slab and Distributing Channel
22'-5"
11'-5"
Section A-A of New Floor

Fig. 3. — Aluminum-alloy floor framing and ribbed slab surfaced with asphaltic concrete reduce the dead load of Smithfield St. Bridge by more than 1 ton per linear foot.

a number of years, but never as a major part of a bridge. Nevertheless, the fact that structural aluminum could be obtained with strength characteristics equal to those of structural steel, but at a saving of 65 % in weight, made possible the design of a floor system which, according to best judgment, would add some 25 years to the life of the bridge — in other words to the limit of safe prediction from the traffic standpoint. Considered in another way, the reduction of dead load would justify an increase of live load without exceeding present stresses and would allow certain existing restrictions on traffic to be removed.

New floor designed like steelwork.

In general, the design of the aluminum floor beams and stringers is similar to that of corresponding steel members, except that more attention than usual was given to saving material. The floor beams, 39 inches deep in the street-car roadway and 42 inches deep under the crown of the vehicle roadway, are spliced just east of the center truss, as were the old floor beams, to facilitate erection without interrupting the street-car service, as the car tracks were shifted to the vehicle roadway during replacement of the railway floor system. On the street-car side there are four load-carrying stringers, one under each rail, and two side stringers serving as wind chords, all 36 inches deep. The track stringers are reduced in depth toward the end by bending the bottom flange upward from the middle bracing panel, in order to save weight.

The floor system of the highway side of the bridge consists of a 7/16-inch tread-plate as decking, supported by 7-inch channel joists spaced 8 inches on centers, which joists rest on intermediate and main floor beams. The effective span of the joists is 9 ft. 2 1/2 in. At the middle of each of these joist spans, a tranverse 8-inch channel is rigidly attached to each of the joists as a distributing member, to cause several joists to cooperate in carrying a wheel

Fig. 4. — The aluminum roadway floor ready for surfacing.

load and thus give to the entire floor system the action of a deep slab. The arrangement of the supporting framing and the construction of the slab floor are shown in figure 3. A pavement or surfacing of cold-laid asphaltic mixture, 1 1/2 inches thick, forms the wearing surface of the roadway; the projections of the aluminum deck plate provide an anchorage to prevent the surface material from creeping under traffic.

Like the roadway, the sidewalks are carried by aluminum-alloy framing and decking. The surface is 1/2 inch of cold-processed asphaltic paving on a smooth 1/4-inch aluminum-alloy plate reinforced

Fig. 5.
Erection of the new aluminum bridge was much the same as steel erection. However, the light weight of the material facilitated operations.

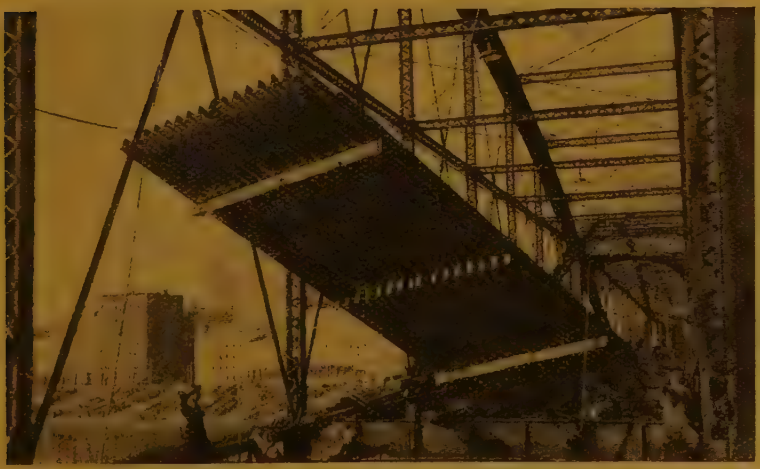


Fig. 6.
Fully assembled panels of the ribbed roadway slab set into place as single pieces.

Fig. 7.
Fully assembled section of the sidewalk set into place.

by 2 × 2-inch angles riveted to the under surface. This plate is supported by 6-inch channels resting on plate-girder stringers which in turn rest on extensions of the main floor beams outside the trusses. The sidewalk hand-rail also is of aluminum alloy, but of a different composition from that of the floor material, to give higher corrosion resistance. Its design adds materially to the attractiveness of the bridge. The top rail is oval tubing 5 inches wide, the bottom rail a 4-inch channel, and the balusters of 1 1/2-inch tubing spaced 6 3/4 inches on centers, expanded into the top and bottom rails by a tool similar to the ordinary boiler-tube expander. The assembled railing was erected in 9-foot lengths, between 5-inch H-beam posts riveted to the outside of the fascia stringers. Because of the high resistance to atmospheric corrosion of the hand-rail material, no painting will be required.

Hot-driven steel rivets, 5/8 to 7/8 inch in size, were used throughout the work. The operation of shearing, punching and reaming in the shop, riveting, fitting and drawing together with drift pins in the field, etc., involved no methods or problems essentially different from those of steel bridge work. Reaming required only the lightest air tools on the market. While the aluminum alloy on the floor system is more resistant to corrosion than the steel or wrought iron which it replaced, nevertheless all the structural members are painted with a priming coat of iron oxide and zinc chromate paint covered with two field coats of aluminum paint.

Material and stresses.

The physical properties of the aluminum alloys employed in the reconstruction of the Smithfield St. Bridge are given in the accompanying table. For a number of years the Aluminum Company of America has been experimenting with and developing a new structural alloy, commercially designated as 27 ST. After the design had been developed on 17 ST, but before work had actually begun, this new alloy was made available to the trade. In addition to its superior physical properties, it is more resistant to corrosion than is 17 ST. It also possesses other properties that make it particularly adaptable for structural work. It was, therefore, substituted for 17 ST but without changing the design.

The design of the floor system was based on the use of the strong aluminum alloy, 17 ST. The design stress was fixed

PHYSICAL PROPERTIES OF ALUMINUM ALLOYS USED ON SMITHFIELD ST. BRIDGE.

Alloy	4 SH	53 ST	27 ST	17 ST
Ultimate strength	42 000	36 000	60 000	58 000
Yield point	38 000	30 000	50 000	35 000
Elongation in 2 inches	3	12	12	20
Brinell hardness	80	80	118	100
Where used	Tubing for hand-rail.	Rolled shapes for hand-rail.	All floor members.	Basis of design.

at 15 000 lb. per sq. inch in tension and compression. The stress on compression members was reduced for unsupported lengths according to formulas which take into account the modulus of elasticity of the material but are otherwise similar to those customarily used in steel design.

The maximum deflections in the floor system of the Smithfield St. Bridge are

limited as follows : floor beams, 1/400 of span; stringers, 1/600 of span; roadway deck, 1/500 of span; and sidewalk deck plate, 1/100 of span. These conservative deflections result in stresses less than the permissible design stress in certain of the members.

Floor slab under load test.

As already stated, the ribbed floor slab was originally designed by the Aluminum Company of America, but before it was proposed for use in the Smithfield St. Bridge it was subjected to extended load test. A panel of ribbed floor slab, 13 ft. 10 in. by 11 feet, was built over a masonry pit in a heavily traveled truck driveway and tested under H-20 loading.

Stresses and deflections in all parts of the structure were accurately measured. These tests resulted in the substitution of 7-inch channels, spaced 8

Fig. 8. — Asphaltic surfacing laid on the roadway slab was compacted by rolling.

inches on centers, for 8-inch channels, spaced 11 inches on centers. The remarkable effectiveness of the transverse 8-inch channel in distributing concentrated loads over a number of the longitudinal channels and preventing differential deflections was well demonstrated by the test.

Result obtained by reconstruction.

The extent to which dead load and stresses were reduced is shown in the following data :

Combined panel load on 3 trusses of the floor system and floor removed, lb.	119 153
Combined panel load of new system, lb.	61 350
Reduction in weight per panel, lb.	57 803 (28.9 tons).

There being 26 panels in the bridge (two spans), the total reduction in weight was 751.4 tons, or a little over 1 ton per linear foot of the bridge.

The panel load of the new system is subdivided as follows :

Aluminium, lb.	26 200
Steel rivets, lb.	3 000
Other steel, lb.	400
Total metal, lb.	29 600

Sidewalk surfacing, lb.	3 000
Roadway surfacing, lb.	9 000
Railway track structure, lb. . . .	19 750
Total weight, lb. . .	61 350

With regard to the permissible loading on the bridge, vehicular loads have been limited to vehicles of 13 tons on four wheels prior to the reconstruction. The new floor has been designed to carry 20-ton trucks on four wheels. With regard to the street-railway side, the type of car in general use weighs from 66 000 to 70 000 lb. Prior to the reconstruction, a regulation has been enforced requiring an interval of 50 feet to be preserved between street-cars operating over the bridge. With the reconstructed floor, this required spacing can be reduced or perhaps entirely eliminated. The floor system is designed for occasional cars weighing 90 000 lb., since the street railway company has actually operated such cars in the past and may find it necessary to do so again.

Cost and construction.

Proposals for the floor reconstruction were received on July 12, 1933, and the contract was awarded to Walter S. Rae, of Pittsburgh, the subcontract for the fabricated structural aluminum to the Aluminum Company of America, and the fabrication itself to the Fort Pitt Bridge Works. The total contract price was $ 276 436, of which $ 192 000 was for the fabricated aluminum. The cost was covered by a ten-year 4 1/4 per cent serial bond issue of $ 300 000, whose ultimate cost to the city will be $ 370 125. This latter figure may be considered the total cost to the taxpayers of delaying for 25 years the building of a new bridge. As traffic conditions may change radically in the meantime, and the possible construction of a rapid-transit subway system would doubtless affect any bridge plan, the present estimate of the cost of the new bridge under conditions of today might be placed at $ 1 250 000. These bonds, if of the type sold for the reconstruction work but extending over a period of 25 years, would cost the city $ 1 935 000. The taxpayer has therefore saved by the adoption of the aluminum floor system the sum of $ 1 564 875, or more than the estimated first cost of the new bridge.

The contract provided that construction be carried on under a schedule limiting the diversion of vehicular traffic to a period of 24 days. Pedestrian and street-car traffic had to be maintained throughout this period. All work was done according to a prearranged and planned program. The details of these operations will be described in another article.

This improvement was made under the direction of Edward G. Lang, director, and the writer, as chief engineer of the department of public works of Pittsburgh. Ross M. Riegel is division engineer of bridges, and Henry D. Johnson, Jr., is engineer of construction. J. P. Growdon was in charge of the work for the Aluminum Company of America, and C. G. Schade, chief engineer, for the Fort Pitt Bridge Works, which handled the fabrication.

[621.132.8 (.44) & 621.43 (.44)]

The new internal-combustion-engined railcars of the French State Railways,

by HENRY MARTIN,
Ingénieur des Arts et Manufactures.

(*Le Génie Civil.*)

The French State Railways put into service, during the summer of 1933, a certain number of railcars driven by spark or compression ignition engines. These railcars, built to widely different designs, will enable comparative trials to be carried out with a view to their extended use on various lines of the system.

Moreover, the requirements of these different lines are hardly alike : on the main lines such as Paris-Havre, Paris-Cherbourg, and Paris-Trouville, high-speed cars which will give an average speed exceeding 100 km. (62 miles) an hour have to be used. On secondary lines with little traffic, cars with much lower speeds will be used.

We can, therefore, consider that the introduction into service of rail motor cars of differing types has been for experimental reasons. Before making general use of this new method of working, the State Railways' management decided to submit a series of new designs of cars to long-period trials, so as to be able to collect definite figures of the operating and maintenance costs.

The builders supplied vehicles some having spark ignition engines, and others compression ignition engines using heavy oil. Generally speaking, the principal preoccupation of the builders has been lightness of construction.

Scheider railcars.

Before describing these modern railcars we will refer to the Schneider railcars in use on this railway system since 1922. Some of these cars are still running on lines with light traffic (Fougères to Pontorson, Lisieux to Orbec).

These vehicles were the result of rebuilding old four-wheeled side-door second class carriages. The two trailing end compartments were retained, and these seat twenty passengers. In the forward end of the vehicle a S.O.M.U.A. 4 cylinder (135 mm. = 5 5/16 in. bore, and 170 mm. = 6 11/16 in. stroke) petrol engine developing 85 H.P. at 1 300 r. p. m. was fitted. This motor drives the leading axle through a clutch and four-speed gear box.

These railcars which cannot be reversed, weigh 14 1/2 t. (14.3 Engl. tons) empty and 16 1/2 t. (16.2 Engl. tons) loaded : they can reach a speed of 75 km. (46.6 miles) an hour on the level. With a trailer this speed falls to 50 km. (31 miles) an hour. On a gradient of 1 in 50 the car can haul 10 tons at 25 km. (15.5 miles) and hour. The petrol consumption is 50 litres per 100 km. (17.7 Br. gallons per 100 miles). Since they were first put into service, the eleven vehicles of this kind have run 1 300 000 km. (807 800 miles).

Michelines.

The particular feature of the Michelines (figs. 1 to 3) is the use of special pneumatic tyres invented by the Michelin Company, details of which were given in the *Génie Civil* of August 1 (1)

(1) See also *Bulletin of the Railway Congress*, January 1932.

Fig. 1. — 36-seater *Micheline* railcar 1933 type, French State Railways.

1931, page 111. The first railcar of this type was demonstrated to the railway company in 1931. It is fitted with a 4-cylinder sleeve valve Panhard engine developing 85 H.P. under test at 2 200 r. p. m.

The vehicle is carried on three pairs of wheels: two driving pairs at the front end, and one bissel truck at the trailing end. It weighs 5 400 kgr. (11 905 lb.) loaded and the maximum speed on the level is 100 km. (62 miles) an hour. The number of seats is 18.

In May 1932, a new 24-seater Micheline was put into service; this unit has a light body on two bogies (fig. 2). The leading bogie is six-wheeled (the two leading pairs being driven) with a 4-wheeled carrying bogie at the trailing end.

The use of the pneumatic tyres involves some multiplication of the number of wheels so as not to exceed the limited wheel loading : if this rule is departed from the wear of the tyres becomes very rapid.

The 4-cylinder sleeve valve Panhard motor is the same as the one used on the 18-seater, and is carried directly on the leading bogie which it drives.

Fig. 2. — Plan of 24-seater *Micheline*, 1932 type.

Note : Soute à bagages = Luggage compartment.

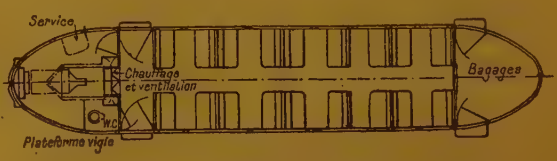


Fig 3. — Plan of the reversible *Micheline*, 1933 type.

Note : Plateforme vigie = Look-out platform. — Chauffage et ventilation = Heating and ventilation. — Bagages = Luggage.

The body, separated from the driving compartment by a bellows diaphragm, is

pivoted on the leading bogie. The part reserved to the passengers is in the middle : at the front and back ends luggage compartments are provided. Passengers enter and leave by two side doors opening inwards and located against the luggage compartments. The seats arranged to face another are separated by a central gangway.

These vehicles which cannot be reversed weigh 4 500 kgr. (9 920 lb.) empty and 6 500 kgr. (14 330 lb.) loaded; they can run at a speed of 90 km. (56 miles) an hour on the level.

The wheels are fitted with special 33 × 4 1/2 tyres with a width on the tread of 125 mm. (4 29/32 inches). They are fitted with an interior ring with the object of preventing the tyre from becoming flat if punctured. The guiding action on the rails is obtained by means of metal discs which take the place of the usual flanges of the steel tyres.

36-seater Micheline. — The 36-seater Micheline (figs 1 and 3) of similar construction to the 24-seater differs chiefly from the latter by being reversible. It has a driving compartment fitted with an elevated look-out so that the driver can watch the line in either direction. The body is carried on two bogies both 6 wheeled; the first bogie is the driving bogie and the second a carrying bogie only.

The railcar is fitted with a 12-cylinder Hispano engine developing 200 H. P. under test at 3 000 r. p. m.

The weight empty is 6 000 kgr. (13 230 lb.) and loaded 9 800 kgr. (21 600 lb.). The maximum speed is 105 km. (65.3 miles) an hour on the level and 60 km. (37.3 miles) an hour on gradients of 1 in 100 to 1 in 50.

Renault railcars.

The French State Railways are using at the present time three types of railcars, supplied by Messrs. Renault, which are fitted with Renault Diesel engines. The wheels run on steel tyres : some types have rubber between the tyres and the centres.

1930 type railcars. — These railcars, put into service by the State Railways in 1931, are used on secondary lines in hilly districts.

They provide seats for 36 passengers and can run at speeds of 85 km. (52.8 miles) on the level and 68 km. (42.2 miles) on gradients of 1 in 66. They are fitted with a 6-cylinder Diesel engine giving 85 H.P. at 1 500 r. p. m. The railcar, which can run in one direction only, is carried on four wheels, the leading pair being the carrying and the trailing the driving pair. The transmission is mechanical, through a gear box giving four speeds forward and one reverse, and cardan shafts.

The braking is by mechanical servomotor (driven by the motor) operating brake blocks on the tyres. The vehicle is heated by the exhaust gases circulating through radiators arranged in the passenger compartments alongside the body sides.

These vehicles weigh 10 000 kgr. (22 040 lb.) when empty and 12 500 kgr. (27 550 lb.) in working order.

Light streamlined railcar, 1933 type. — This railcar which has seats for 34 passengers (fig. 4), differs from earlier ones by the streamlining of the body, which has made it possible to reach higher

Fig. 4. — 34-seater *Renault* railcar.

Note : P. T. T. = Post Office. — Moteur = Engine. — Conducteur = Driver. — Compart^t... = Luggage compartment, 37.7 sq. feet.

speeds; it has a 100-H.P. instead of 85-H.P. motor and can run at 97 km. (60.3 miles) an hour on the level, 70 km. (43.5 miles) an hour on gradients of 1 in 100 and 60 km. (37.3 miles) an hour on 1 in 66 gradients. The empty and loaded weights are respectively 12 000 and 15 000 kgr. (26 450 and 33 070 lb.).

For the sake of simplicity a single driving compartment has been provided as in the earlier type. This arrangement, moreover, fits in better with the streamlined form of the body which has to be unsymmetrical. The wheel base has been made 4.50 m. (14 ft. 9 in.) so that the ordinary turntables can be used.

The six-cylinder Renault Diesel engine differs from the older type by the increase in the cylinder bore from 115 mm. (4 33/64 in.) to 125 mm. (4 29/32 in.) (stroke 170 mm. = 6 11/16 in.).

A mechanical servo-motor brake is fitted, and an electro-magnetic brake in addition. The vehicle fully loaded can be stopped on the level, from an initial speed of 90 km. (56 miles) an hour, in 150 m. (164 yards).

The consumption of gas oil is 20 litres per 100 km. (7.08 Br. gallons per 100 miles). Particular attention was given, when building these railcars, to reduce all noises to a minimum. As in the case of modern road motor cars, the engine is carried on large rubber blocks. In addition the body sides and floor are lined with sound deadening materials.

Railcars of this type were put into service during the Summer of 1933 between Dinan and Dinard (21 km. = 13.1 miles). The average time of the run is 25 minutes instead of 39 minutes in the case of the regular steam trains. The overall speeds are 52 km. (32.3 miles) an hour for the express cars and 45 km. (28 miles) an hour for the cars stopping intermediately.

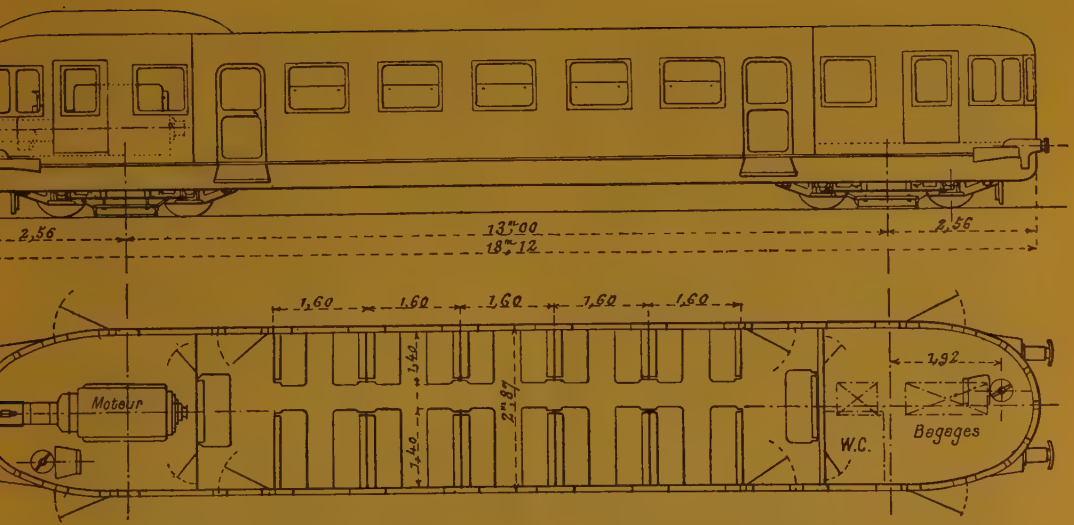
Express railcars, V. H., 1933 type. — The railcars of this type (figs 5 to 7) are all-metal. They have seats for 56

Fig. 5. — Type VH *Renault* railcar, with Diesel engine.

passengers and can carry about 1 000 kgr. (2 200 lb.) of luggage. The speed on the level is 120 km. (74.6 miles) an hour. The tare weight is about 21 t. (20.7 Engl. tons) and the weight in running order 26 t. (25.6 Engl. tons).

The railcar is carried on two four-wheeled bogies; the leading bogie is driven directly by the motor placed over it in the driver's compartment; the trailing bogie is a carrying bogie only.

The streamlined body reduces air resistance to a minimum, as in the earlier type. The particular feature of this new design is the introduction of an « engine block » carried in a cradle inde-



Figs. 6 and 7. — Elevation and plan of a type VH *Renault* railcar.

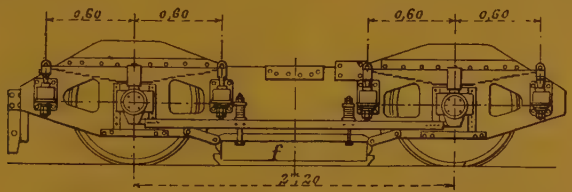


Fig. 8. — Driving bogie of *Renault* railcar.

pendently of the frame (fig. 9) so as to facilitate repairs. The cradle is carried on the frame through rubber blocks which damp out the motor vibrations. As the cardan shafts are very short, they only transmit small vibrations.

The block, consisting of the motor, the clutch and the gear box, can be with-

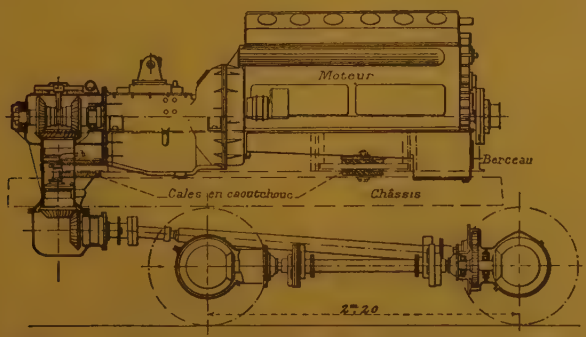


Fig. 9. — Engine and transmission of *Renault* railcar.

drawn readily by removing the front panel of the body and the radiator.

The Renault Diesel engine has 12 cylinders in a V block, the bore being 130 mm. (5 1/8 in.) and the stroke 170 mm. (6 11/16 in.). This engine, at 1 500 r. p. m., gives a normal output of 250 H.P., which can be increased for a short period to 310 H.P. It is a four-stroke engine, and the compression ratio is 1 to 16 and the corresponding compression is 35 kgr./cm² (498 lb. per sq. inch). The fuel is injected into the cylinders at 250 kgr./cm² (3 555 lb. per sq. inch) pressure. The consumption of gas oil is 45 litres per 100 km. (15.94 Br. gallons per 100 miles).

The cylinder and crank case is in aluminium in one piece. The cylinders are fitted with liners in special cast iron. The valves and fuel injection nozzles are arranged in the heads which are water-cooled. Each cylinder has a separate head to allow for free expansion.

The distribution is by a single cam shaft with 24 cams, gear driven off the crank shaft. This cam shaft operates the air admission valves and the exhaust valves through intermediate rockers.

The engine is fitted with a centrifugal governor which cuts off the injection of fuel when the number of revolutions exceeds the maximum allowed.

The clutch consists of two lightened steel discs attached to the primary shaft of the gear box, one on each side of a fixed centre plate secured to the engine flywheel.

The gear box has four speeds with a reversing gear arranged at the back of the box proper. This arrangement makes it possible to use the four constant-mesh gears in both directions of running, and consists of a group of three large toothed coned wheels (two on the horizontal shaft and one on the vertical driving shaft). By means of a system of dog clutches one or other of the two coned wheels on the horizontal shaft can be used to transmit the drive and thereby reverses the direction of running.

The vertical shaft in turn drives, through bevel gears, the inclined shaft driving the two driving axles (fig. 9) which are coupled together by conical pinions and a horizontal shaft. Transmission of the movement from one shaft to the other is through gears. The inclined shaft has two universal joints, so that the bearing springs can deflect freely. The shaft connecting the two axles also has two flexible couplings.

The distance between the bogie centres is 13 m. (42 ft. 8 in.); the wheel base of each bogie is 2.20 m. (7 ft. 2 5/8 in.). The wheels, 0.85 m. (2 ft. 9 1/2 in.) in diameter, are monoblock chrome-molybdenum steel forgings; the tyre profile is that of the French railways. New cars are under consideration, with elastic wheels having an insert of rubber between the tyres and the wheel centres in order to reduce noise.

The bogie spring gear consists of laminated springs with rubber auxiliary springs. S.K.F. roller bearing axle boxes are fitted.

Owing to the short bogie base, the railcars can run through curves of a minimum radius of 80 m. (4 chains).

These railcars, which can run in either direction, have a driving compartment at both ends; they are fitted with two brakes, the ordinary compressed-air brake and the electro-magnetic brake. The first acts on all four wheels, four brake cylinders being fitted; this brake also can be applied by a hand wheel. The electro-magnetic brake has four shoes *f* (fig. 8) fitted between the bogie wheels and acting on the rails; it is used for emergency braking. The rail coach can be stopped in 150 m. (164 yards) from a speed of 95 km. (59 miles) an hour on the level.

The combined frame and body is built up of two trellis girders which form two sides of the body. These girders which are carried up to the side lights are con-

nected to the frame through an elastic material. The frame longitudinals are built up of bent plates; in principle they have nothing to do with the strength of the vehicle, as this is provided for by the trellis girders entirely. The girders and the superstructure of the body are built up of bent plates welded electrically; as a result, it has been possible to effect a considerable reduction of weight without diminishing rigidity.

The outside of the body is covered with aluminium sheets. The floor is of corrugated aluminium sheeting with compressed cork inserted in the corrugations. A thick layer of celotex is also used to prevent noises and vibrations from penetrating into the passenger compartment.

The passenger compartment has seats for 56 passengers, and there is room for 10 standing. The exhaust gases are used for heating. The electric light is obtained from a 850-watt dynamo and a buffer battery of nickel-cadmium cells.

During the trials on the State Railways, these fast railcars covered the Dreux-Argentan run and back (230 km. = 143 miles) at the average speed of 109.5 km. (68 miles) an hour, Paris-Dieppe and back (402 km. = 249.8 miles) at the average speed of 104.5 km. (64.9 miles) an hour, and Paris-Deauville and back (440 km. = 273.4 miles) at the average speed of 105 km. (65.6 miles) per hour. These vehicles were put into regular service between Lisieux and Trouville and provide a shuttle service at hourly intervals throughout the day. The run of 30 km. (18.6 miles) is made in 20 minutes in the express working, representing an average speed of 90 km. (56 miles) an hour (the fast trains are allowed 28 minutes for the run).

The service is normally covered by one car which runs 900 km. (559.2 miles) during the day. At the busy hours, a second car is put into the working : the day's run of the two vehicles is then 1 500 km. (932 miles).

Railcars of the same type have also been put into service this Summer on the Alsace-Lorraine, Est, Paris-Orleans and Paris-Lyons-Mediterranean Railways. On the last named, the trials where made over heavily graded lines. Average speeds of 80 km. (50 miles) an hour were worked on the Lyons-Grenoble section in both directions.

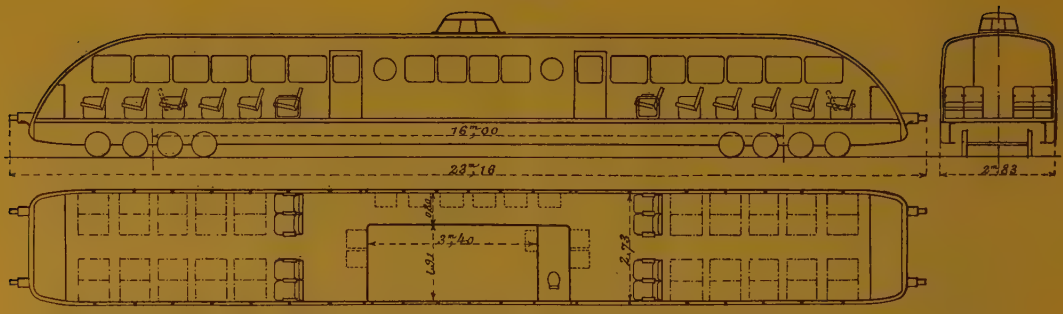
The consumption of gas oil varied between 38 and 40 litres per 100 km. (13.45 and 14.16 Br. gallons) ; the corresponding consumption of oil was estimated to cost 8 francs (12.90 francs per 100 miles).

Bugatti railcars.

When building this vehicle, Mr. Bugatti's idea was to provide a vehicle capable of reaching the highest speeds attainable on present-day railway lines, whilst providing the passengers with the greatest possible degree of comfort. The vehicle had therefore to have great stability at speeds up to 175 km. (109 miles) an hour and at the same time noise and vibration, so difficult to prevent in relatively light railcars, had to be avoided.

The following details are taken from the description of this railcar, given by Mr. Ferrand, Engineer, of the State Railways, in the *Revue Générale de chemins de fer* for August 1933. The car consists of a streamlined body on a strong frame built up of pressed steel members, carried on two bogies, each having two driving and two carrying axles. The object of this design, using four axles, is to reduce the amplitude of the vertical and side movements of the end axles before they are transmitted to the pivot and then to the body.

In order to obtain the very high speed mentioned, the designer thought it preferable to use a group of four motors of the Royal-Bugatti type, of 200 H.P., parallel to one another, and at right angles to the longitudinal axis of the vehicle; this group is placed at the centre of the vehicle.



Figs. 10 to 12. — Section and plan of *Bugatti* railcar.

Fig. 13. — Petrol-engined *Bugatti* railcar.

Each motor is a straight eight. At the end of each crank shaft a clutch is fitted: the four clutches are controlled by the same operating gear. At the end of each clutch, there is a reversing gearbox fitted will bevel gears, with Gleason cut teeth. By moving a lever, the bevel gears are displaced in one direction or the other, so as to give forward or backward running; in the intermediate position the motors run idle.

Each group of two motors drives the nearer bogie. In addition one, two or three engines can be cut out if anything goes wrong with them.

The motors run on either mixtures of petrol and alcohol, or of petrol, benzol and alcohol.

The Bugatti railcar had no gear box originally. The very high torque from the 800-H.P. motor group should make it easy to start directly.

In order to facilitate station work involving many stops and extremely slow speed, a gear box was fitted to two of the motors, giving a reduction of 4 to 1. The other two motors drive directly without intermediate gearing.

The two inside axles of each bogie (figs. 14 and 15) are driving axles, and the two outer simply carrying. The power is transmitted to the axles through bevel gears.

The bogie consists of a rigid steel plate frame on two groups of laminated springs attached to the frame through Silent blocks.

The carrying axles have loose wheels,

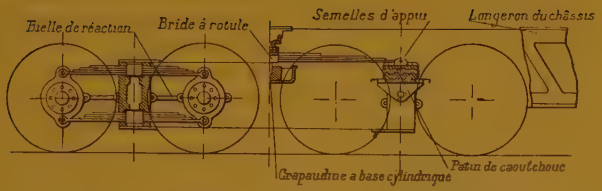


Fig. 14. — Spring gear of an eight-wheeled bogie.

Note : **Bielle de réaction = Thrust link. — Bride à rotule = Spherical pivot. — Semelles d'appui = Bearing blocks. — Longeron du châssis = Frame longitudinal. — Patin de caoutchouc = Rubber pad. = Crapaudine à base cylindrique = Circular center bearing.**

Fig. 15. — Eight-wheeled bogie of *Bugatti* railcar.

those on the motor axles being keyed on. The wheels are 0.71 m. (2 ft. 4 in.) in diameter with steel tyres (fig. 16). Three rubber rings *a*, compressed one against the other to damp out vertical vibrations, are fitted between the tyre and its centre.

The tyres are secured to the centres by bolts passing through rubber rings *c* intended to damp out the vibrations resulting from the wheel being driven. The assembly is completed by rubber discs *b* damping out the lateral shocks. The wheels carry in addition a brake drum *t* on which the ferrodo-lined sections bear.

The frame is supported on the bogie by two large laminated springs arranged longitudinally, which bear on slides fitted

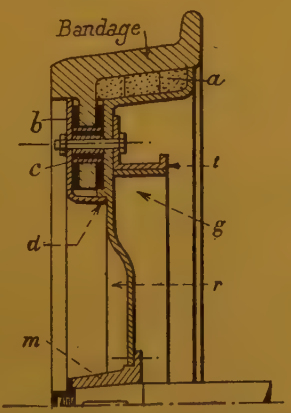


Fig. 16. — Section of a driving wheel of the *Bugatti* railcar.

Bandage = Tyre. — *a*, *b*, *c*, rubber rings; *d*, cover; *g*, packing; *m*, boss; *r*, wheel centre; *t*, brake drum.

on the bogie frame. Rubber blocks between the spring shoes and the slides damp out the vibrations from the rails.

The motion of the bogie is transferred to the body by a central pivot which has no other function to fulfil, and which is therefore independent of the system of supporting it and of the springing. This pivot is a spherical one bearing on a piston moving in an oil-filled cylinder. Holes drilled in the piston obstruct the circulation of the oil, and in this way the vertical oscillations are absorbed. The base of the cylinder is carried in a spherical center bearing fastened to the bogie frame. The top of the cylinder is connected to this frame through blocks of rubber fastened to the frame.

The body, also of steel, is built up of five separate sections. The centre portion houses all the machinery, the driver's compartment, the luggage compartment, and the lavatory. The end sections retain the same cross section, but the height falls towards the ends to reduce air resistance.

Mr. Bugatti has found this design better than the method of streamlining the body on the sides, as the air currents pass over the coach rather than along the sides. He expects to avoid in this way any side blow resulting from the compression of the air between the two vehicles when two railcars of this design pass one another.

The end sections and the centre section are connected by intermediate sections : all these sections are connected together through rubber packings fitted up under considerable compression. The five sections therefore are free to move relatively to one another, whilst the joints remain tight owing to the elasticity of the rubber packings. The doors are arranged in each of the four intermediate sections. The sides and roof are metal and are double; they are interlined with celotex.

The body is supported on cup-shaped brackets rigidly attached to the longitudinals. These brackets take the spherical pivots fastened to the body through rubber pads.

As we have already pointed out, the driving compartment is arranged at the centre of the vehicle. From his raised position the driver can readily watch the line in either direction through a lookout which projects sufficiently above the roof for the purpose, whilst remaining within the loading gauge; the depressed shape of the ends of the vehicle also makes it easier to watch the track close to the vehicle.

The driver has conveniently to hand the throttle, the clutch lever, and the reversing gear control, as well as the compressed air brake valve handle and the hand brake wheel. He has before him, as on a road motor car, an instrument board with the various indicating and control devices.

The brake action is transmitted from the brake cylinder piston to the cams operating the blocks through a floating lever operating two sets of brake rigging placed in the driver's compartment.

The fuel tanks are carried under the frame. They consist of a tank of 125 l. (27.5 Br. gallons) for each engine, or 500 l. (110 gallons) in all. These tanks are of the three-envelope undeformable aircraft type.

The body (figs. 10 to 12) has two passenger compartments, each seating 24 passengers.

The lights are fixed, ventilation being obtained by a fan drawing fresh air from the outside and forcing it through ducts which discharge through openings under the seats. In winter, this air is heated by making it circulate over the cooling water radiators.

During its trials, the Bugatti railcar gave average speeds of 166 to 172 km. (103 to 107 miles) an hour, the maximum speed reaching 180 km. (112 miles) an hour. The speed record of the Berlin-

Hamburg rail motor coach (160 km. = 99.5 miles an hour) has therefore been beaten (1).

As regards the brake efficiency, the tests gave stops in 340 m. (372 yards) from 100 km. (62 miles) an hour. At speeds of 120 km. (74.5 miles) and 150 km. (93 miles) an hour, the stopping distances were 400 and 700 m. (437 and 765 yards respectively.

The tests also showed that the stability of the vehicle was at least as good as that of the most modern bogie vehicles running at the maximum legal speed of 120 km. (74.5 miles) an hour.

As a result of these favourable tests, the Bugatti railcar was put into regular service last summer on the Paris-Trouville-Deauville line. The car left the St. Lazare Station at 1.50 p. m., arrived at Trouville at 3.50 p. m., left at 6.45 p. m. and was back in Paris at 8.45 p. m. It took therefore exactly two hours to run in each direction, a distance of 221 km. (137.3 miles) without stopping, corresponding to an overall speed of over 110 km. (68.3 miles) an hour.

« Charentaise » type railcar.

The « Compagnie des Entreprises Charentaises » wich had previously tried, on the Midi Railway, a railcar known as the « Pauline » (2), built for the State Railways a new rail motor coach of the same kind, with a passenger compartment to seat 55, and a luggage compartment (figs. 17 to 19).

Fig. 17. — *Charentaise* railcar, with Diesel motor.

The principal preoccupation in designing this prototype was lightness. With this object in view, it was decided not to use bogies. The appearance of the carriage is nonetheless that of a bogie carriage, as each end of the frame is carried on two pairs of wheels and axles connected by two longitudinals joined together at their centre by a bolster. This latter has been given some elasticity by reducing one flange of the rolled section at a point in its length. The two axles are naturally very close together, as they have to function as a single pair of wheels and axles.

The streamlined body, in duralumin, is supported by the wheels and axles through a secondary frame, also in duralumin.

The vehicle is driven by a three-cylinder Diesel motor made by the « Compagnie Lilloise de Moteurs » giving 80 H.P. at 1 000 r. p. m. The drive is transmitted, through a five-speed gear box, to the two inner pairs of wheels.

(1) This German railcar was described in the *Génie Civil* of April 8, 1933, page 317. See also *Bulletin of the Railway Congress*, November 1932, p. 2076.

(2) See on this subject a note in the *Génie Civil* of April 2, 1932, page 351.

Figs. 18 and 19. — Elevation and plan of the *Charentaise* railcar.

Note : Combustible = Fuel. — 55 places assises = Seats for 55. — Banquettes rabattables. — Drop seats. — Siège = Seat. — Fourgon = Luggage compt^{t}. — Coffre P. T. T. = Post office box.

The railcar, which can be run in either direction, is fitted with a driving compartment at each end; the motor is installed in the leading compartment. The layout of the car includes a lavatory arranged besides the leading-end driving compartment. At the trailing end, there is a luggage compartment measuring 10 m² (107.6 sq. feet), against the second driving compartment.

The vehicle weighs light 10 100 kgr. (22 260 lb.) and in running order 15 300 kgr. (33 700 lb.). The speed is 90 km. (56 miles) an hour on the level, 63 km. (39.1 miles) on 1 in 100, and 50 km. (31 miles) on 1 in 66. The eight wheels are braked hydraulically.

A railcar built on the same lines has already run 40 000 km. (24 850 miles) on the Midi system.

Express railcar built by the « Aciéries du Nord ».

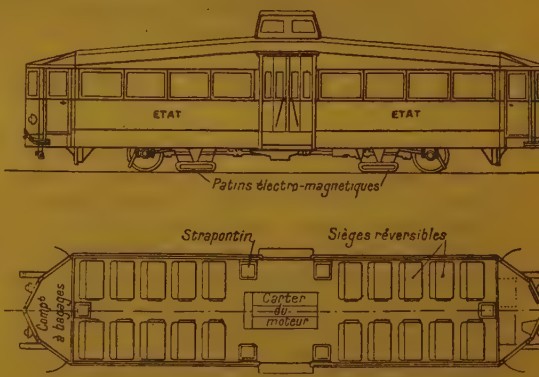
This railcar has places for 76 passengers, including tip-up seats, a luggage compartment, and a lavatory. As it can run in both directions, a driving compartment is fitted at each end.

A six-cylinder Diesel M.A.N. engine of 175 mm. (6 29/32 inches) bore and 180 mm. (7 3/64 inches) stroke has been fitted.

This new railcar has not so far undergone its trials on the State Railways.

Railcar built by the « Compagnie Générale de Construction ».

These railcars (figs. 20 and 21) are carried on 4 pairs of wheels only. They are driven by 6-cylinder 140-H.P. M.A.N. Diesel engines. The motor is arranged with the single driving compartment at the middle of the vehicle. The roof



Figs. 20 and 21. — Elevation and plan of the railcar built by the *Compagnie Générale de Construction*.

Note : Patins électro-magnétiques = Electro-magnetic rail brake shoes. — Strapontin = Folding seat. — Sièges réversibles = Reversible seats. — Compt. à bagages = Luggage compartment. — Carter du moteur = Casing over motor.

slopes downwards at each end from the look-out in order to give a better view.

The weight in running order is 13 500 kgr. (29 760 lb.) and the maximum speed is 90 km. (56 miles) an hour. Both pairs of wheels are driven; they run in S.K.F. roller bearing axle boxes.

The brakes are : oil-pneumatic, hand, and electro-pneumatic, the latter acting on the rail.

The frame is arc-welded throughout. The body is fitted with 44 reversible seats and the sides are glazed above the waist rail.

A depressed platform is arranged at each end; one carries the luggage compartment and the other is reserved for post office use. The platforms are depressed so as not to impede the view of the passengers along the track.

S.O.M.U.A. Company's railcar.

The State Railways will shortly put into service two railcars built by the S.O.M.U.A. Company (Société d'Outillage Mécanique et d'Usinage d'Artillerie), on three pairs of wheels (figs. 22 and 23), each consisting of two bodies articulated near the middle pair of wheels. Actually the unit consists of a four-wheeled carriage to which has been added a two-wheeled vehicle. In this way the use of bogies

Fig. 22. — S.O.M.U.A. railcar of the State Railways.

Fig. 23. — Plan of S.O.M.U.A. railcar.

Note : Cabine de conduite = Driver's compartment. — Fourgon à bagages = Luggage compartment. — Compt. voyageurs = Passenger compartment. — Places assises = Seats.

has been avoided, whilst free running through curves of small radius has been retained.

The four-wheeled unit carries the M.A.N. 6-cylinder Diesel engine with 140-mm. (5 1/2 in.) bore and 180-mm. (7 3/32 in.) stroke cylinders giving 105 H.P., and the driving mechanism. The other body is supported on the first through friction plates, spring control-

led, to limit the relative movement of the two parts.

The articulated coupling consists of a central spherical joint, and the continuity of the body is provided for by means of a bellows connection.

A driving compartment is provided at each end of the unit. The different controls are operated pneumatically Silent blocks are fitted in all pins in the spring gear. In addition, shock absorbers are fitted, as on road motor cars, connecting the axles to the frame; they damp out oscillations and make it possible to use flexible springs.

The wheels include the S.O.M.U.A. shock absorbing device, the tyres being connected to the centres through pins fitted in Silent blocks.

The four-wheeled section has a very large luggage compartment, and a passenger compartment to seat 30. In the other section, there is a lavatory and a passenger compartment for 47, so that there are seats for 77 in all. The heating is from a small oil boiler of the type used in apartment houses.

This railcar will undergo its first trials very shortly.

We will content ourselves with these few details of the rail motor coaches actually under trial on the State Railways. Similar trials are in hand on the other railways, but not with so great a variety of types. Vehicles are also under construction or design by other builders, such as Citroën, Hispano Suiza, de Dietrich, etc...

It will be interesting to learn the comparative results shown by pneumatic and steel tyres, which latter can be improved, as we have seen, by inserting rubber between the tyre and the centre. The use of pneumatic tyres is obviously a very good way to prevent the setting up of vibrations which are so disagreeable to the passengers in a light car. Against this there is the disadvantage of having to limit the axle weight carefully with the result of multiplying the number of axles, if wear of the pneumatic tyre is to be obviated. From an operating point of view, there are also slight drawbacks due to the yielding of the tyres, such as failure to explode detonators or to operate more or less regularly the detector bars. In the event of the short circuiting of the rails by the wheels and axles being used for track signalling purposes, pneumatic-tyred vehicles must be fitted with additional equipment. The same problem arises when vehicles are fitted with wheels with rubber between tyre and centre.

On sections of line with heavy gradients, it will also be interesting to see how the motors are cooled; from this point of view the tests on the Paris-Lyons-Mediterranean over heavily graded lines will give useful information.

We can see already that the requirements as to comfort are met well enough provided, however, that standing passengers are not allowed. In view of the small number of passengers who can be carried in these vehicles and the obligation of using two men, one of whom can cover the unit in the event of failure on the open track, the operating and maintenance repair costs must also not exceed certain limits.

[621. 335 (.42) & 621. 43 (.42)]

200-H.P. Diesel-electric railcar,

London, Midland & Scottish Railway.

(Engineering.)

The 200-H.P. Diesel-electric railcar, which has been running for some time on the Warwick-Daventry-Northampton branch of the London Midland and Scottish Railway, both as a single unit and with trailing loads, such as passenger vehicles and horse-boxes, and has more recently been operating on the Watford-St. Albans branch of the same railway, has been built entirely at the Preston, Rugby and Bradford works of the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2. It has been specially designed for branch line working, and experience has shown that it is quite capable of hauling a standard 27-ton trailer coach and of carrying out any shunting that is likely to be necessary. A general view of this vehicle appears in figure 1 hereafter. It is 62 ft. 10 1/2 in. long over the buffers, and 59 ft. 6 in. long over the body, the overall width and height being 8 ft. 11 3/8 in. and 12 ft. 11 1/2 in. respectively. Its weight in working order is 37 1/2 tons, and its maximum speed 60 m.p.h. As regards construction, the underframe is of rolled steel sections, which are braced

Fig. 1. — General view of vehicle.

and gusseted, while the swing bolster at the engine end is carried from four links with nests of spiral springs and rubber shock absorbers, so as to reduce the vibration. The bogie under the engine compartment is of plate frame construction and carries the two axle-hung driving motors. The trailing bogie is built up of steel sections. All the axle boxes are fitted with roller bearings. The body is of steel with ash fittings in the pillars, and the outer panels, which are also of steel, are secured by mouldings of the same material. The interior, a view of which appears in figure 4, is furnished in mahogany and bubinga, with mahogany mouldings, and the metal fittings are chromium-plated. The seats are upholstered in figured moquette. Access to the passenger compartment is obtained through a central entrance, which is provided with sliding doors, and a vestibule.

Fig. 2. — Driver's cabin.

At present there is seating accommodation for 53 passengers, but this could be increased to 61. The engine compartment with one driver's cab is at one end of the coach, being divided from the passenger compartment by a luggage space, while at the other end is a second cab. The partition between this cab and the passenger compartment is glazed above the waist line, so that a sort of observation saloon is formed. At night this partition can be covered by a blind. The engine compartment, a view of which appears in figure 3, is of steel throughout and is fitted with a removable roof so that the power unit can be lifted out for major overhauls. Where there is not sufficient room for this, the end of the body can be taken away and the power unit drawn out on rollers.

The engine, which is of English Electric design, is of the six-cylinder Diesel type, with mechanical injection, and has an output of 200 H.P. at 1 500 r. p. m., though it is capable of an output of 220 H.P. for 15 minutes. Running speeds of 1 200 r.p.m. and 900 r.p.m. are also provided. Cooling is effected by a centrifugal pump, which is driven from the crankshaft, and by a radiator, which also incorporates an oil cooler. The engine speed is controlled from a master controller through solenoid-operated valves, which admit oil under pressure to the cylinders on the governor and thus alter the setting and timing of the latter. If the oil pressure fails, the engine is automatically shut down. As shown in figure 5, the engine is direct coupled to a 135-kw. generator, the complete unit being carried on trunnions, so that a three-point suspension is obtained. The bearers and fixing bolts are insulated from the underframe by rubber, so that the minimum of noise and vibration is transmitted to the coach. The exciter is mounted separately, in order to reduce the length of the set, and is chain driven.

The control gear, which comprises the

Fig. 3. — Engine compartment.

Fig. 4. — Interior of car.

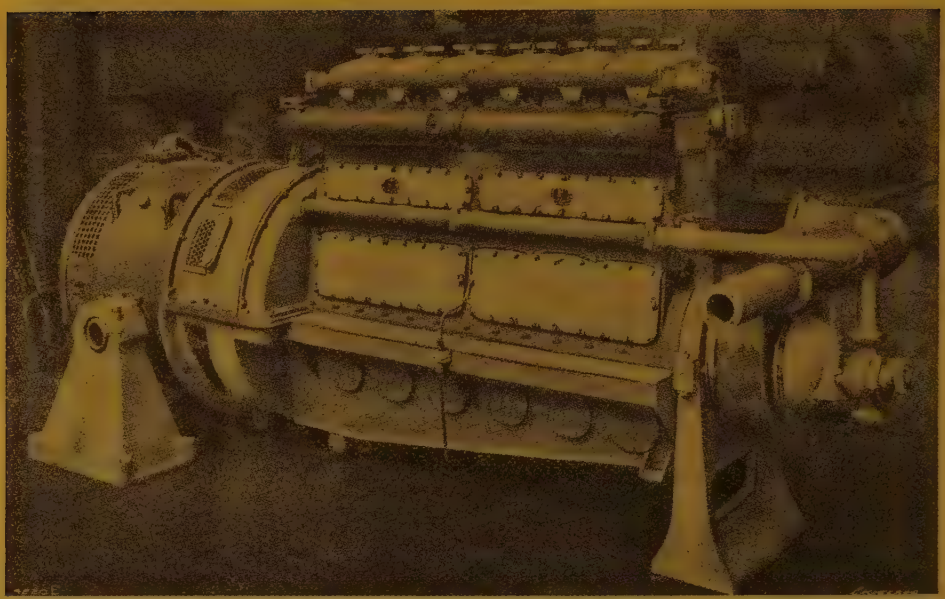


Fig. 5. — 200-H.P. power unit.

reverser, motor contactors, and battery cut-out, is mounted on a framework over the generator, as shown in figure 3. The necessary connections to the cables are made by terminal bars, so that the frame can be disconnected and dismantled as a unit. The car is fitted, with vacuum brakes, acting on all the wheels and a screw-down hand brake, which acts on the wheels of the driving bogie. The necessary vacuum is obtained from an electrically-driven exhauster in the driving compartment.

The vehicle is arranged for one-man control from a master controller, which is fitted with a dead man's handle, as can be seen in figure 2, which shows one of the driving compartments. The engine is started by a push button switch, which connects a battery to the generator, so that the latter runs as a motor. Successive movements of the controller then bring the engine speed up to 900 r.p.m., 1 200 r.p.m., and 1 500 r.p.m., and finally full vehicle speed is obtained by adjusting the generator and motor fields. When the controller handle is moved back the weak motor field is retained until the idling notch is reached, thus combining economy of power with the maximum electrical output. The engine can be shut down by bringing the master controller handle to the « off » position. The main electrical system is designed so that the full output is automatically maintained over a very wide range of train speed and without any risk of the engine being overloaded. Signal lights are provided to show that there is adequate lubricating oil pressure and that the water circulation is working correctly.

The car is heated from a low-pressure boiler, which is fired with engine fuel oil and supplies steam to radiators under the seats in the passenger compartment, the condensate being returned through a feed tank. If the flame is extinguished or the water level falls below a certain limit, the oil supply is cut off. The feed

pump is also controlled by the water level. This system has been adopted to enable heat to be supplied when the engine is not running. Standard hose couplings are fitted at each end of the railcar, so that any passenger coach which is used as a trailer can be heated.

We understand that during the five weeks ended November 11 the car ran 5 880 miles with an average fuel consumption of 6.26 miles per gallon, this figure including shunting, shed movements and other incidental running.

[621. 335 (42) & 621. 43 (.42)]

Armstrong-Whitworth 880-H.P. oil-electric locomotive for experimental use on the London & North Eastern Railway.

(From *Modern Transport.*)

A further stage in railway traction development in Great Britain is exemplified by an 880-B.H.P. oil-electric locomotive, built by Sir W. G. Armstrong, Whitworth and Co. (Engineers), Limited, of Scotswood-on-Tyne, for service on the London and North Eastern Railway. Although not the most powerful yet built, the oil-electric locomotive — drawings and photographs of which are reproduced hereafter — inasmuch as it is intended for use, when required, with one or more similar units, is claimed to represent a step towards the utilisation of greater powers than are possessed by the heaviest existing steam locomotives.

It is not only in regard to the flexibility afforded by the unit type of locomotive (one, two or more units being coupled together and driven by one crew), but by its versatility that the new oil-electric locomotive is claimed to be unique. The patented electric transmission, for instance, permits full utilisation of the power of the oil engine at speeds varying between 6 and 60 m.p.h., and thus the locomotive is suitable for heavy goods trains scheduled at 20 m.p.h. average speed, and fast passenger trains running at a maximum of 70 m.p.h. Trains such as the 600-ton Anglo-Scottish expresses are beyond the ability of two such units, and consequently the higher powered engines would be necessary. Apart from these, the whole range of trains in Great Britain, from heavy mineral to fast passenger, is claimed to come within the scope of the units when used either singly or double headed. In the case of the majority of overseas railways, where speeds in excess 60 m.p.h. are rare, all locomotive duties are claimed to be covered by units of this power, the principal details of which are as follow :

Power of main and auxiliary engines	880 B.H.P.
Weight in working order	72 tons.
Maximum axle load	17 tons.
Tractive effort	28 500 lb.
Maximum speed	70 m.p.h.
Loading gauge	A composite British loading gauge.
Length over buffer beams	36 ft. 6 in.
Fuel capacity	900 miles, passenger working. 500 miles, goods working.

The main dimensions are as shown in the accompanying drawing (fig. 3).

Fig. 1. — General view.

Fig. 2. — The engine generator set being lowered into the locomotive.

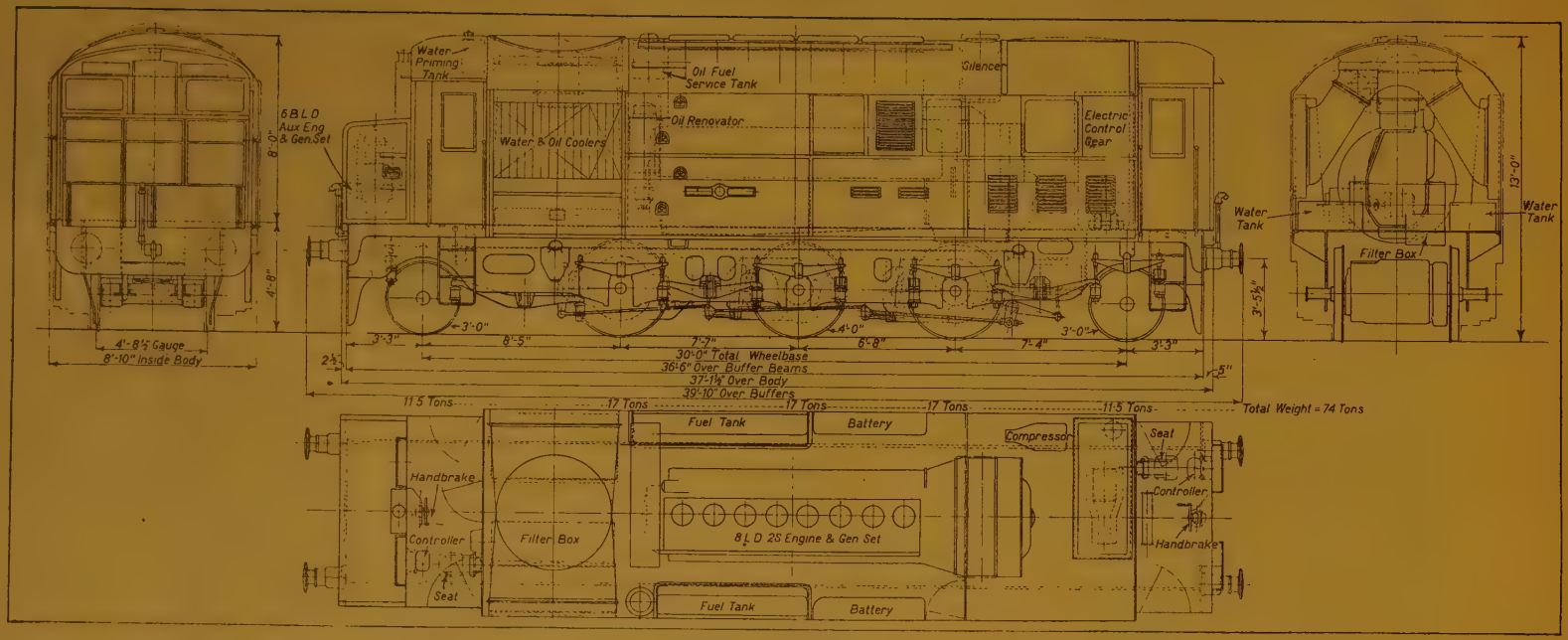


Fig. 3. — Elevation and plan drawings showing general arrangement.

Mechanical features.

A locomotive of the rigid wheelbase type and of 2-6-2 wheel arrangement, guided by single-axle pony trucks, has been evolved in preference to the bogie type owing to the high speeds required, for whereas the bogie type, when two units are permanently articulated together, as in the case of the Buenos Aires Great Southern Railway Company's locomotives, is capable of speeds of over 80 m.p.h., the short distances between bogie centres precludes this arrangement being adopted in the case of units to be used singly. The 2-6-2 type unit, it is stated, runs equally well in either direction, arrangements having been made to avoid complete symmetry by using different designs of pony truck and truck springs at the two locomotive ends. Compensation is carried out between one pony and its neighbouring driving axle, and between the other pony and the remaining two driving axles. The driving wheels are of 48-inch diameter and truck wheel diameters are 36 inches, Isothermos axleboxes (12 in. by 5 1/2 in.) being employed. Braking is, of course, by vacuum, with couplers for connecting to passenger stock, and is effected by a Consolidated Brake rotary exhauster acting through 24-inch Westinghouse cylinders. Compressed air sanding is fitted.

The structure is built up on 1-inch plate frames with cross stretchers at suitable intervals, and is capable of supporting the engine generator set upon what is virtually a three-point support. The body is formed of steel sections and sheets in which welding has been employed to a great extent. No extreme measures have proved necessary in keeping the weight down to the adhesion necessary. Triplex safety glass is employed for the windows of the driver's cab, and Artic glass for the engine-room lights. A section of the roof is removable for the purpose of lifting out the main engine set during locomotive overhauls, and the auxiliary engine is accommodated under a bonnet at one end of the vehicle, the bonnet, though of robust construction, being hinged and easily lifted. The ventilation of the interior of the locomotive is ensured by partitioning off the engine from the generator, and allowing the generator to draw in cool air through louvres and then to discharge it into the engine-room proper, whence it escapes through the roof ventilators.

Armstrong-Sulzer engine.

The engine is a British-built eight-cylinder Armstrong-Sulzer Diesel engine of a size similar to that used on the Ceinture Railway, Paris. Two cast-iron cylinder blocks are built up on a welded steel crank chamber, which forms, with the circular extension of the generator, what is virtually a single tubular unit comprising engine and generator which can be lifted out of the locomotive, and which, when resting on an elastic seating, provides the three-point support previously mentioned. Separate cylinder heads, each with valves in removable cages and separate fuel pumps and valve gear, are provided for each cylinder. Full power is developed at 700 r.p.m., and two reduced speeds are provided for medium power and for idling, though, with the arrangements made for continuous easy starting of the main engine, the idling speed is only used to a limited extent when in regular service. The cylinder liners are of cast-iron, the pistons of forged aluminium alloy, and the connecting rods are chrome nickel steel forgings. Cooling is effected by a direct-driven pump circulating the water through Serck radiator elements, elements also being provided for lubricating oil cooling. As in all Armstrong-Whitworth locomotives of high power, these elements are arranged on each side of the locomotive with ducts leading up to a single fan placed in the roof; in this case a Davidson « Aeroto » fan, motor-driven and thermostatically controlled,

has been used. Fuel tanks are arranged on each side of the engine-room. An interesting feature is the fitting of a streamlined lubricating oil renovator, which obviates the necessity of drawing off oil, cleansing it in suitable renovators in the running sheds, and returning it to the locomotive. This filter, being in constant use, allows of only occasional make-up oil having to be added, amounting, on the average, to 1 % of the fuel oil used by the engine.

Electrical transmission and control.

The main generator of the oil-electric locomotive is of Laurence Scott manufacture, and three Crompton-Parkinson roller-bearing traction motors are incorporated. Control apparatus supplied by both firms was built to Amstrong-Whitworth specifications and patents, and is suitable for the « constant-horsepower » system developed by the latter. The control is entirely self regulating, and the driver's duties are confined to attention to the road and manipulation of the single controller handle and of the brake valve. It is stated that when on the full power notch of the controller the output of the oil engine is automatically regulated with plus or minus 3 1/2 % of the nominal horse-power. Where an assistant driver is carried, this is solely for the purpose of relief, and normally the engine-room door is not opened except at terminal stations. When two units are coupled together, no crew is carried on the second locomotive. A « deadman's handle » is fitted, and, where desirable, this may take the form of the Armstrong-Whitworth delayed action device, which allows the driver to leave his controller to accept tokens in single line working.

Tests with passenger and goods trains of varying loads and speeds have been made by courtesy of the London & North Eastern Railway Company, on the Newcastle-on-Tyne to Edinburgh line and on the Carlisle route,and have, it is claimed, demonstrated the suitability of the locomotive for the regular service it has to perform. Two similar units are now under construction at the Scotswood-on-Tyne works of Sir W. G. Armstrong, Whitworth and Co.(Engineers), Limited, and these, when completed, will enable the builders to claim to have produced the most powerful oil-electric locomotive in Great Britain.

[621.132.3 (44) & 621.132 5 (.44)]

New 2-10-0 four-cylinder compound locomotive for fast and heavy goods and passenger trains, Nord Railway, France.

(From *The Railway Gazette.*)

There is at present under construction in the workshops of the French Nord Railway a series of 30 new locomotives, Nos. 5.1201-5.1230, Type 150, which embody a number of interesting features and are capable of remarkable running performance. The new locomotives are four-cylinder compound, high-pressure, high-superheat machines built primarily for the haulage of heavy goods trains (trailing load 2 165 tons) at speeds of 60-70 km. (37.3-43.5 miles) an hour on the level, but designed also to be capable of working heavy express trains. The principal dimensions of these locomotives are as follow :

Cylinders :	
Diameter, H.P.	490 mm. (19 5/16 inches).
Diameter, L.P.	680 mm. (26 3/4 inches).
Stroke, H.P.	640 mm. (25 3/16 inches).
Stroke, L.P.	700 mm. (27 9/16 inches).
Coupled wheels, diameter	1 550 mm. (5 ft. 1 in.).
Bissel wheels, diameter	950 mm. (3 ft. 1 3/8 in.).
Boiler :	
Working pressure	18 hectopièzes (261 lb. per sq. inch).
Heating surface, tubes and flues	175.68 m² (1 890 sq. feet).
Heating surface, firebox	20.30 m² (218 sq. feet).
	195.98 m² (2 108 sq. feet).
Heating surface, superheater	61.01 m² (656 sq. feet).
Total.	256.99 m² (2 764 sq. feet).
Grate area	3.48 m² (37.4 sq. feet).
Wheelbase, rigid	5 320 mm. (17 ft. 5 1/2 in.).
Wheelbase, total engine	9 480 mm. (31 ft. 1 1/4 in.).
Weight of engine in working order	104 t. (102.33 Engl. tons).
Adhesion weight	90 t. (88.55 Engl. tons).
Water capacity	38 t. (8 360 Imp. gall.).
Fuel capacity	Over 9 t. (about 9 Engl. tons).
Maximum theoretical tractive effort :	
Compound	27 057 kgr. (59 660 lb.).
Simple	35 207 kgr. (77 630 lb.).

The guiding principles of the design are those which have been followed by the Company in a number of its recent constructions, particularly the *Pacific* type 3.1251-90 (1) and the suburban *Mikado* tank type 4.1200 (2). The boiler in the new locomotives is that of the 3.1251-90 type with the pressure increased from 17 to 18 hectopièzes (246 to 261 lb. per sq. inch) and a high superheat

(1) Described in *The Railway Gazette* of March 17, 1933. (See also *Bulletin of the Railway Congress*, June 1933, p. 573.)

(2) Described in *The Railway Gazette of* February 19, 1932. (See also *Bulletin of the Railway Congress*, August 1933, p. 710.)

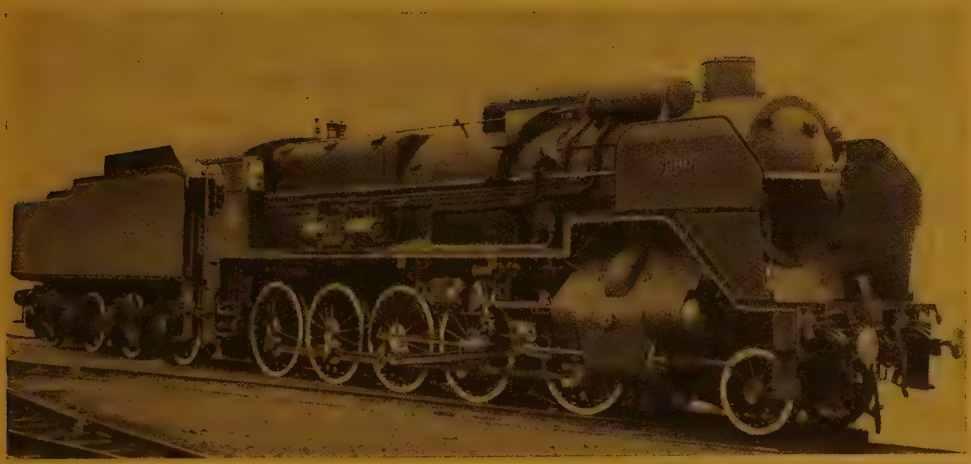


Fig. 1. — New Nord 2-10-0 mixed traffic locomotive.

of 380°-390° C. (716°-734° F.) in normal operation, rising to 420° C. (788° F.) in forced working. The distance between tube plates is 4 500 mm. (14 ft. 9 1/4 in.) and there are thirty-six 45/50 mm. (1.77/1.97 inch) smooth tubes; sixty-five 65/70 mm. (2.56/2.76 inch) Serve tubes; and thirty-two 135/143 mm. (5.32/5.63 inch) flues.

The four-cylinder engine with two outside high-pressure and two inside low-pressure cylinders, is designed specially for high-speeds of rotation. The cylinders are of cast steel with cast iron liners. Each high-pressure cylinder is cast in one piece with the front portion of the frame and extends to the cross-stay. The low-pressure cylinders and valve chests are also cast in one piece. The piston valves, of light welded-plate construction, are of 300-mm. (11 13/16 inch) diameter for the high-pressure, and 380-mm.(14 15/16 inch) diameter for the low-pressure cylinders. The maximum pressure in the intermediate receiver is 8 hpz. (116 lb. per sq. inch). The steam passages are particularly short and direct, both between the cylinders and on the exhaust side. Various types of variable-section blast pipes have been subjected to comparative trials; and the blast pipe tops are placed as low as possible in the smokebox and surmounted by petticoats.

The frames are of 45-mm. (1 3/8 inch) plate heavily braced by steel castings, and three-point suspension is used. Owing to the provision for lateral displacement to the extent of $\pm$ 65 mm. (2 9/16 inches) on the leading bissel and $\pm$ 15 mm. (5/8 inch) on the rear coupled axle, the 5.1200 locomotives will run on curves down to 145-150 m. (7 1/4-7 1/2 chains) radius. Walschaert valve gear is used and the motion work has been made as light as possible. The high and low-pressure pistons are of nitrided steel, and the coupling rods of nickel-chromium steel. The tender tanks are of welded sheet construction.

Forced lubrication by black oil is provided for the axle boxes of the driving and coupled wheels, and for the low-pressure slide-bars; high-temperature oil carried by steam (hydro-mechanical lubrication) is used for the high and low pressure piston valves and cylinders; and Tecalemit lubrication is applied to

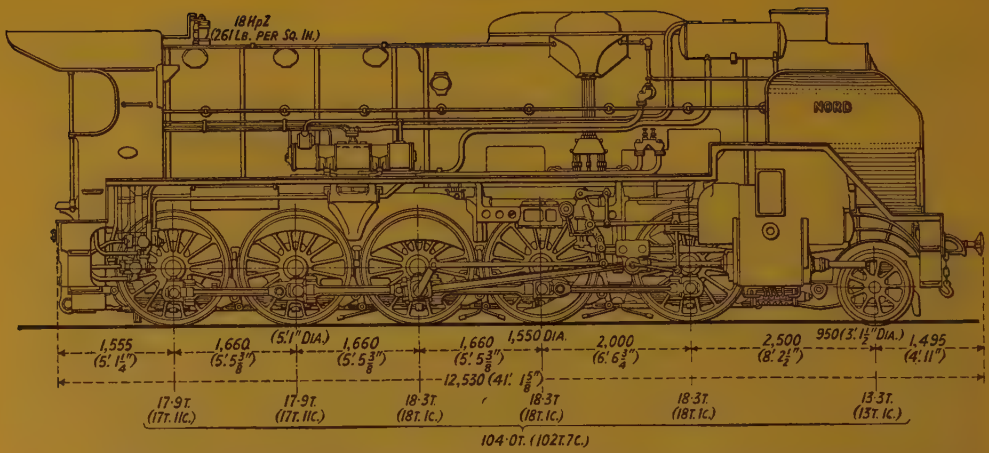


Fig. 2. — General arrangement of Nord ten-coupeld mixed-traffic locomotive.

the bissel and to the connection between locomotive and tender. Westinghouse automatic and direct brakes are provid-

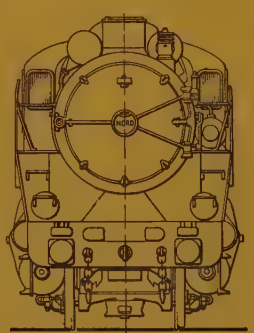


Fig. 3. — End view of new locomotive.

L.P.-cylinders :

Diameter . . .	660 mm. (26 3/4 inches).
Stroke . . .	700 mm. (27 9/16 inches).

H.P.-cylinders :

Diameter . .	490 mm. (19 5/16 inches).
Stroke . . .	640 mm. (25 3/16 inches).

ed, with Leach air sanding gear. A.C.F.I. feed heating equipment is installed, and the superheater is of the Schmidt type.

Results of trials.

Locomotive No. 5.1211, placed in service in July, 1933 regularly hauls express trains between Paris and Maubeuge or Paris and Aulnoye. With train No. 119 on September 13, weighing behind the tender 554 t. (545.2 Engl. tons), this locomotive maintained a speed of 90-95 km. (55.9-59.0 miles) an hour on a gradient of 1 in 200, and reached 110 km. (68.4 miles) an hour on the level. Remarkably rapid acceleration was obtained owing to the efficiency of the engine and the great adhesion of the locomotive.

Trials with coal trains weighing 2 200 t. (2 165 Engl. tons), excluding the tender, were made with locomotive No. 5.1213 between Lens and Le Bourget with a single stop at Longueau. The running times and speeds were :

Lens-Longueau	76 km. (47.2 miles) in 1 h. 38 m. Mean speed, 46.5 km. (28.9 miles) an hour.
Longueau-Le Bourget.	123 km. (76.4 miles) in 2 h. 43 m. Mean speed, 45 km. (28 miles) an hour.

In the course of this run, the locomotive developed 2 000-2 100 ch.-vap. (1 973-2 071 H.P.) at the drawbar and reached a speed of 70 km. (43.5 miles) an hour on the level.

[625. 214]

Roller bearings in rail transport.

Application to locomotives and wagons,

by P. A. HYDE.

(From *Modern Transport*.)

There are many reasons why the roller bearing should be of great interest to the railway mechanical engineer, among these being the reduction in internal resistance of the locomotive itself, thus permitting a larger proportion of the power generated to be applied to the haulage of paying load, and the elimination of wear with certainty of reduced maintenance costs. As a consequence of increased reliability, inspection outside shops can be much reduced, intermediate repairs can be done away with, and, as the intervals between greasings can be enormously lengthened, the amount of lubricant used can be much reduced.

There is, however, great diversity of opinion among railway men as to the value of the roller bearing, especially as this form of bearing, being a precision job, must always cost considerably more than the plain bearing. Actually, the roller bearing axlebox at present costs, for the small quantities usually ordered, about four times as much as the corresponding plain bearing axlebox. The roller bearing must naturally be more expensive than the corresponding plain bearing type of axlebox, but as the demand for the roller bearing increases, and mass production becomes the rule, the price will fall rapidly. This tendency has already become apparent in Germany and Sweden, where on thousands of one type of bearing being ordered, a very material reduction in price became at once possible.

Experimental applications.

In about 1920, attention began to focus on the roller bearing. The first roller bearing axlebox tested in this country was fitted with two rings of rollers, that nearest the wheel being composed of short parallel rollers, while the outer ring was made up of spherical, or barrel-shaped, rollers of the self-aligning type. The inner races in this design were pressed on to the journal and were positioned horizontally by distance rings. One hundred and ninety eight axleboxes of this design were supplied during 1921, the experimenters being the Swedish and German State Railways, Swedish private lines, and the Pennsylvania Railroad. The design may be said to have been the first really successful attempt to apply the roller bearing to railway service, and these early users have continued to apply the roller bearing ever since. By 1922 the Swedish State Railways were apparently satisfied with results, as during that year they ordered a further 1 360 axleboxes, and in this country the Great Northern and Midland Railways ordered 8 and 110 respectively. The total ordered for the year was 1 562. The Great Northern coach is believed to have run some 600 000 miles in fast traffic up to the beginning of 1932. The Midland local train is still in service on the Tilbury branch.

(1) Abstract of a paper read at a meeting of the Institution of Locomotive Engineers, London, on November 23, 1933.

When last examined in 1932 the majority of the bearings were in good condition. During this overhaul some of the parallel roller rings, which were found to be less satisfactory than those of the spherical type, were replaced, making the total number of replacements of parallel rings during ten years approximately equal to 1 % per annum. The spherical roller rings have given, as was anticipated, very much better results, as during the ten years only three rings had to be replaced, the trouble being due to the system of press fits on the axle.

Double spherical bearings.

Experience with this train had, therefore, shown that the parallel roller was not sufficiently robust, and that the system of press fits was unsatisfactory, and in 1924 press fits were discarded and the desirability of having both rings of the spherical self-aligning type had been realised, both on account of standardisation, the self-aligning feature, and on account of the much greater load carrying capacity of the spherical roller. The cost of the spherical roller bearing was at that time high, but improved manufacturing facilities soon permitted of substantial reductions in cost and the double spherical type of roller bearing became, and has remained, the standard for the sliding type of box, in all cases where the load in carried above the centre line of the journal.

During 1924, also, the arrangement of carrying the inner races in taper sleeves was first introduced, thus permitting application and removal of the bearings by the use of hand tools only. With this arrangement, no matter how many times the bearings may be removed, the journal remains undamaged and the fit unimpaired. All fear of movement of the race on the journal is eliminated. The races cannot be burst when fitting, while the machining limits for the journal may be considerably increased.

Taper roller bearings.

The Timken taper roller bearing itself is not truly self-aligning, but it can be housed in a box of the self-aligning type. Originating in the United States as a bearing for motor-car work, this bearing has been developed for railway application with marked success, and it is being widely used in the U. S. A. for all classes of rolling stock and locomotive bogies. In this design the inner races are pressed on to the axle with pressures of from 10 to 20 tons. Another design of bearing, of which some thousands have been applied, is that known as the Hyatt. In this bearing, which is of American origin, the rollers are coiled from steel of rectangular section and have the appearance of a spiral spring. They are the full length of the journal and run on a hard sleeve carried on the journal, which has no collar, the thrust being taken on a bronze pad on the axlebox cover.

A design originating in this country is the Ransome and Marles compound ball and roller bearing, in which the load is carried on plain rollers while the thrust is taken by a ball ring. Where the load can be suspended or the axlebox is fixed, as in a diamond-framed bogie, a single ring self-aligning bearing can be used with advantage, as it is then completely self-aligning.

Advantages in passenger working.

The International Sleeping Car Company, although not primarily concerned with haulage costs have equipped a very large proportion of their coaches with spherical roller bearings, and are continuing to do so, and it may be concluded that, in this case, the reason for their action is reliability and not reduction of resistance. When the class of traffic covered by the local and stopping passenger schedules is considered, the question of fuel or power saving becomes of importance, and experience goes to show

that, in this class of service, savings of from 10 to 14 % can reasonably be expected.

Other arguments put forward are increased availability of stock due to reliability and elimination of hot boxes, freedom from bearing and axle wear, reduced cost of examination, and large savings in cost of lubrication. One administration which has more than 11 000 bearings in suburban service states that the very considerable cost of the complete conversion of its stock has been fully justified by increased reliability, and improved economy in upkeep. A certain French system recently introduced an improved, but heavier, design of local passenger vehicle to replace its older and lighter coaches. The schedule to which this old stock had been worked was the best that could be run with the engine power available, and it was found that time could not be kept with the same number of new coaches per train. Some of the new stock had, however, been fitted with roller bearings, and with trains made up of these roller vehicles it was found that time could easily be kept.

Goods wagons.

Sweden and Germany are, so far, the only countries to equip any large number of goods wagons with roller bearings. One of the objections raised to fitting goods vehicles with expensive roller bearing is the question of interchange, because roller-fitted wagons belonging to one company will, of necessity, be required to spend long periods on foreign lines, when the benefit of the extra capital expended by the owning company, and the easier running of the fitted wagons, will be lost to the owners. A strong argument in favour of the roller bearing is that of safety. Hot boxes are an unmitigated nuisance to all concerned, and are also a source of grave danger, especially abroad, where blocks are very long and hot boxes may run for many miles before they are detected. Accidents due to journals being twisted off are by no means uncommon, and very heavy damage often results. It is known that fires in trains have arisen from this cause.

Locomotive experiments.

Very little has been done outside the United States in the way of applying the roller bearing to locomotives, except in so far as tenders are concerned. Russia and Czechoslovakia fitted a number of tender axles with good results, and the Federated Malay States Railways applied spherical roller bearings to the tender bogies of six locomotives built in 1931. The French State lines have fitted the tender bogies of their last new « Mountain » type locomotives with the same design, while the London Midland and Scottish Railway have also fitted one of their new *Pacific* express engine tenders with the Timken bearing. The New Zealand Government Railways, who have had a good deal of experience with coaching stock fitted with spherical rollers, went into the question of locomotive applications in the United States very carefully, and were apparently so satisfied with results that they fitted S.K.F. bearings to the leading engine and tender bogies of thirty new 4-8-4 engines. The axlebox used in this instance is of the outside design, both for engine and tender bogie, double ring bearings being used. The trailing bogie is a booster bogie and runs on plain bearings.

It is to the United States and Canada that one must look to find the earliest locomotive applications, and the biggest advance in the use of the roller bearing under motive power. In those countries, considerable progress has been made, many lines having large numbers of engines partly equipped, while some of the important lines have even standardised roller bearings for both engine and tender bogies. Initial installations on coupled axles have also been tried with

most satisfactory results. The New York Central was the first line to make trials, the leading bogies of two heavy *Pacific* express engines having been equipped, one with Timken and the other with S.K.F. bearings. The results proved so satisfactory, both as regards reliability and economy, that the policy begun in 1927 has been continued, till to-day nearly 900 spherical roller bearing axleboxes are running under the bogies of the heavy Hudson type express engines on the New York Central. While the New York Central were gaining this experience, the Canadian Pacific and the Canadian National Railways were obtaining like results, and both lines came to similar decisions several years, ago. More than fifteen other railroads in the States have followed their example, and many hundred leading bogies are to-day running on both Timken and S.K.F. bearings.

Timken locomotive.

The next step forward was taken by the Timken Roller Bearing Company who, to demonstrate that roller bearings could be successfully applied to the driving and coupled axles of the heaviest modern locomotives, commissioned the American Locomotive Company to build them a 4-8-4 engine with all its axles carried in Timken roller bearings. The engine was so designed that the weights on the coupled wheels, could be varied to suit different loadings allowed, the maximum axle load being 30 tons. With that load the steam pressure was 250 lb. When delivered, this engine was lent to many of the leading lines to be tested in regular service of all kinds. It ran well over 100 000 miles, hauling passenger trains at speeds up to 75 miles per hour and goods trains of as much as 8 000 tons.

The engine has run with perfect success, and the Timken Roller Bearing Company are to be congratulated on the success of their experiment. The reduction in internal friction is said to be 12 1/2 %. The bearings were lubricated with oil, and the total amount used on bearings was approximately one pint per 100 miles for all axles. The oil in the coupled axleboxes was changed twice during the 100 000 miles, and while the new oil is included in the figure above, the oil is not taken account of.

RECENT DEVELOPMENTS
IN RAILWAY PRACTICE.

[621. 43 (.42)]

The London Midland and Scottish Railway Company's light Diesel-hydraulic railcars for branch line service.

We are indebted to Mr. Stanier, the Chief Mechanical Engineer of the London Midland and Scottish Railway, for the particulars given below of the light railcars recently designed and built to his requirements in conjunction with Leyland Motors Ltd, and recently put into service on that railway.

Particular interest attaches to these railcars, if only because the design shows a very marked break-away from standard railway practice in an effort better to meet the changed conditions now prevailing on secondary and branch line services.

On services of this kind rapid acceleration plays a vital part in giving a fast service, whilst a high maximum speed is, by itself, of comparatively little importance. Therefore one of the primary objects of this design has been to produce cars which shall be light, simple, reasonable in first cost and operation, and above all, have a high rate of acceleration. With this end in view, it was decided, therefore to explore the possibilities of cars on two axles.

As a result of very close co-operation between the two Companies, cars have been produced which weigh only 10 1/2 tons, seat 40 passengers, and reach speeds of 20, 30, 40 and 50 miles per hour in 11, 20, 32 and 49 seconds respectively. Their maximum speed is at the moment governed down to 56 m. p.h., which can be maintained comfortably on stiff normal gradients.

This unusually rapid acceleration is in part due to the high power weight ratio, but is also largely attributed to the performance of the Leyland hydraulic torque converter, described later, which, permitting the maximum horsepower of the engine to be applied during all the period of acceleration, produces an unusually rapid, silent, and smooth getaway, unbroken by gear changes.

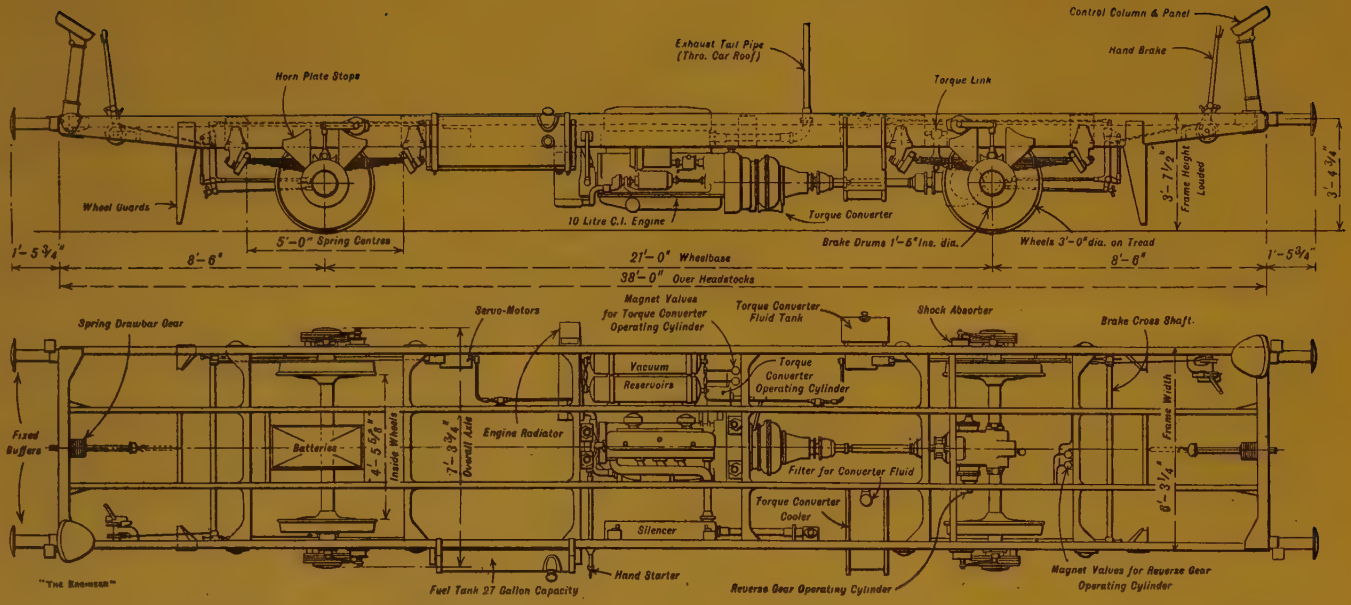
As stated previously, the car is of the two-axle type, one axle being driven. The power unit is a 130-H.P., 6-cylinder, oil engine mounted under the floor; it transmits its drive through the hydraulic torque converter to the axle. Control is very simply effected, from either end of the car, from an instrument board in each driving cabin. The controls include electro-pneumatic mechanism for the operation of the torque converter and reverse gears and mechanical control of the throttle, power brake and hand brake.

An all-steel body, also of Leyland manufacture, is mounted on the steel channel underframe, which has a section of 12 in. × 3 in. × 1/4 in. A feature of this body is the excellent vision given to the passengers, an unobstructed view all round being provided.

Full streamlining of the body with its consequent sacrifice in seating accommodation has not been adopted, because it was considered that seating capacity on a branch line service is of greater importance than the possible increase in speeds which might result from streamlining on the rare occasions when high speeds could be obtained.

The power unit is a six-cylinder compression-ignition oil engine, 4 5/8-inch bore × 6-inch stroke, giving a displacement of 9.9 litres. It develops 130 H.P. at 2 000 r.p.m. at which speed it is governed. It is rigidly bolted at four points to the frame in the centre of the chassis. Its auxiliaries include a 24-volt starting motor, Bosch injection

Fig. 1. — General arrangement of 40-seater rail car.



Drawing reproduced from *The Engineer*.

Fig. 2. — Arrangement of chassis.

equipment, governor and fuel filter, and a lubricating filter. Water circulation is effected by a pump through a vertical radiator disposed transversely across the frame towards the rear of the engine. The circulating water can in addition be by-passed to thermostatically controlled heaters in the car.

A vacuum exhauster for the operation of the brakes and controls in addition to a separate auxiliary electrically operated exhauster, is mounted on the engine.

The hydraulic torque converter (Lysholm-Smith system) which is now being manufactured in large quantities by Leyland Motors Ltd, for use on road motor vehicles, is bolted to the engine and transmits power to the driving axle by means of an open propeller shaft fitted with « Spicer » couplings.

This hydraulic system of power transmission has many advantages. Compared with electrical systems it is more simple, less costly and lighter, and, though its performance has all the advantageous characteristics, it gives if any thing smoother acceleration and, in operation, is more efficient owing to the provision of a direct drive which eliminates all losses. With this system, as

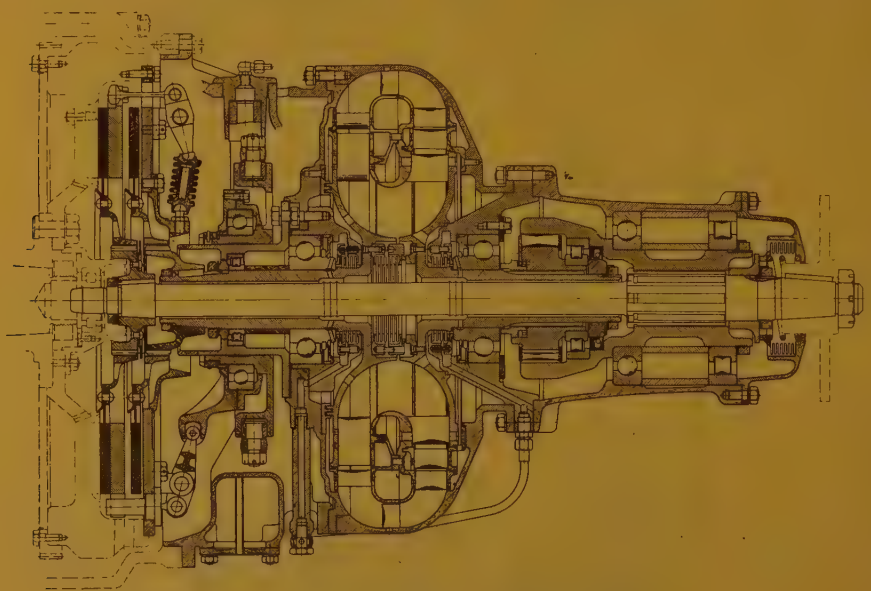


Fig. 3. — Hydraulic torque converter.

opposed to the gearbox, torque conversion is entirely automatic, so that remote control is simplified. Further, as all action between the driving and driven members is purely hydraulic, it is not subject to wear and its silence and smoothness must of necessity continue.

The function of the torque converter is to multiply the engine torque and give an automatic variation of torque with speed depending on the operating conditions. The importance of this cannot be overestimated, as control of the car with the exception of throttle manipulation requires no skill on the part of the driver.

While it is quite possible to drive through the converter at all times, there are obvious advantages in providing a direct drive for use at cruising speeds. An additional drive of this type is, therefore, provided.

The drive from the engine is taken through one or other of two friction clutches. The clutch disc nearest to the engine is mounted on a shaft passing through the centre of the converter to the axle and provides the direct drive. The second clutch disc is mounted on a hollow shaft, the other end of which is connected to the impeller inside the converter casing, so forming the drive to the converter.

The clutches are used as couplings only; they do not take up the drive as in the conventional clutch and are, therefore, subject to little wear. Though not strictly necessary, an intermediate position is provided in which both clutches are disengaged. It will, therefore, be seen that there are three positions of the two-way clutch on the converter, (*a*) the hydraulic-drive position, (*b*) the neutral position, (*c*) the direct-drive position, with the hydraulic drive stationary. These three positions are obtained by utilising a double-acting vacuum cylinder controlled by magnet valves, to provide the fore-and-aft movement of the clutch pressure-plate. The control of the magnet valves is from a three-way switch at each end of the car through the medium of a small converter controller which picks up the neutral position of the clutches by hunting contacts, or cuts off the current from the magnet valves when the clutch has completed its travel in either direction.

The torque converter consists essentially of a centrifugal pump mounted in a single casing with a three-stage hydraulic turbine. The pump member is similar in form to the impeller of the familiar water-circulating pump. The turbine, which is connected to the driving axle through the free-wheel described later, consists of a bladed rotor on which three separate rows of blades are fixed in such a position that they are divided by two rings of stationary blades fixed to the casing.

The casing is completely filled with fluid so that when power from the engine is transmitted to the pump, the fluid is driven from the pump on to the first set of rotor blades, then through stationary blades, where its flow is redirected on to the second set of rotating blades, through stationary blades, where its direction is again changed, on to the third set of moving blades and so back to the pump. Owing to the shape of the blading and the fact that the fluid impinges on three sets of blades coupled in series, torque can be increased up to the ratio of 4.8 to 1.

Labyrinth seals are used in the design to prevent short-circuiting of the fluid between the rotor and casing. Other seals are included to prevent loss of fluid. Slight leakage is, however, encouraged for the purpose of lubrication, but the fluid so passed is collected in a small sump and automatically returned to the reserve tank.

To ensure the removal of any air or vapour which may be liberated by the converter fluid during operation or when filling up, a small pipe is carried from the top of the converter casing to an ejector fitted in the reserve tank. Whenever the converter is running, fluid flows through the pipe to the ejector, the other entry of which is coupled to the drainage sump, and thus automatically returns any leakage past the seals to the reserve tank.

The function of the reserve tank is, of course, to keep the converter full of fluid under all conditions of operation. In order to secure maximum efficiency, it is advantageous to maintain a minimum pressure in the casing of about 30 lb. per sq. inch and, therefore, fluid from the reserve tank is fed to the converter through an injector. This injector is worked by means of fluid short-circuited from two points in the converter, which have an appreciable pressure difference.

In order to limit the temperature rise in the working fluid under extreme conditions of operation, a small cooler is placed on the frame side and connected in parallel with the fluid circulation.

Fig. 4. — Interior of body.

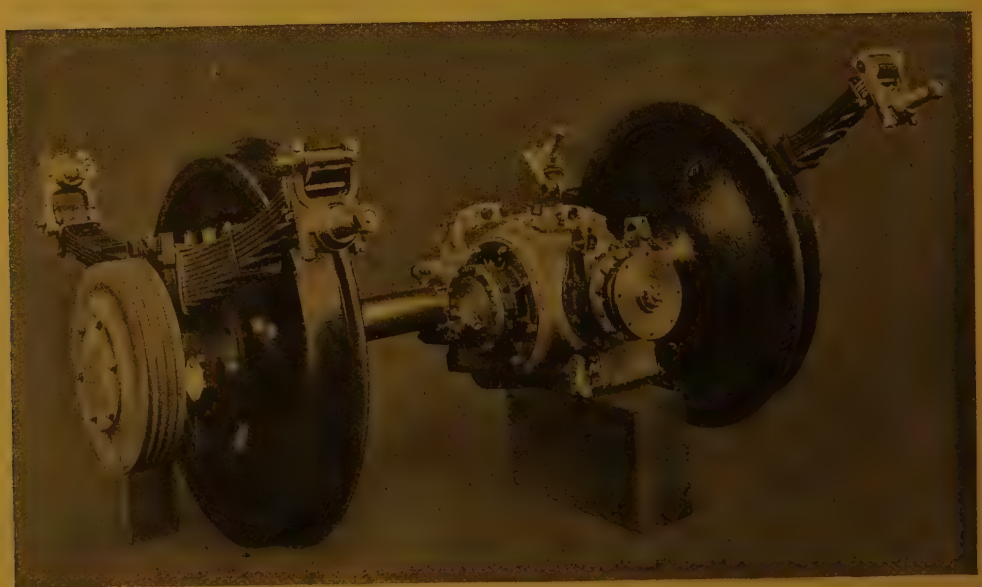


Fig. 5. — Rear axle.

In this circulation is also a by-pass filter.

The fluid used in the converter consists of a mixture of paraffin and 5 % of light spindle oil or of ordinary fuel oil as used for compression ignition engines.

A free-wheel is provided on the shaft driven by the turbine rotor. Thus the converter is completely isolated and comes to rest immediately its clutch is disengaged, so permitting a direct drive in which there is no hydraulic loss. Also, it makes coasting possible when the converter drive is engaged.

The free-wheel is of the well-tried cam-and-roller type in which a number of rollers, positioned in recesses round the inner or driving member, are used to lock the outer ring member. The inner member is driven by the converter and the outer is coupled directly to the propeller shaft. The free-wheel unit is of ample proportions and, taking its drive only through the hydraulic system, works under ideal conditions.

The gearing on the driving axle is carried in an aluminium casing mounted in such a way that the casing and all parts (with the exception of the generously-proportioned spur gear which is pressed on the axle shaft) can be dismantled without removing the wheels from the axle. The gearing consists of a simple double-reduction gear in which all bearings are lubricated under pressure by a pump in the casing and the whole assembly, therefore, requires the minimum of attention. Spiral bevel gears are used in the first reduction and ground spur gears in the second reduction. The spur pinion can be meshed with either of the two bevel wheels by means of internal teeth so as to provide reverse gear of the same gear ratio.

The forward or reverse motion is controlled by magnet valves, operated from a switch in the driver's cab, applying vacuum to either side or a two-way vacuum cylinder which moves the pinion from one bevel to the other. As it is necessary for the train to be at rest before the direction of the gearing is changed, the control operating this is interlocked with the torque converter switch which must be in the neutral position before the former can be moved.

The axles are fitted with light cast-steel wheels having a diameter of 3 feet over the tread. They are carried in roller bearings in the axle boxes.

The braking system is on all four wheels and can be applied by either power or hand. Unlike the usual railway type of shoe brake which is responsible for a certain amount of tyre wear, internal expanding fabric-lined shoes are adopted which operate in four 17-inch drums located on the axle ends outside each wheel where they are readily accessible and are well cooled by the movement of the car. The power brake is applied by vacuum, the valve of which is controlled mechanically from the driving compartments, whilst the hand brake is of a patented double-ratchet type, a mechanism which has been well proved on Leyland heavy vehicles and with which it is possible to obtain great leverage and at the same time release the brake little by little, or completely as desired.

A considerable weight reduction is shown by the suspension adopted as compared with the usual railway construction. Semi-elliptic springs are used, a feature of which is the anchorage at each end. This can perhaps be best described as a swinging link, universally jointed at one end and free to move longitudinally at the other. This arrangement allows the axle to follow the curve of the rail and at the same time permits of a restrained sideways movement to cushion any shock received at the wheel flange when passing over points. Brackets are also fitted which limit the fore and aft movement of the axle, but do not normally take part in its constraint.

The controls, with the exception of the handbrake lever, are mounted in a compact group on a control column, one of which is installed in a separate cabin at

Fig. 6. — Springing and brakes.

each end of the car. All controls are « fool proofed » by interconnection and so simple is their operation that it has been found possible for a driver to take over control of the car after only fifteen minutes tuition. They consist of :

2 levers for operating the throttle and the power brake;

1 change-over switch for the electro-pneumatic control of the torque converter to give neutral, direct drive or the drive through the hydraulic system;

1 change-over switch for the reversing gear;

2 press buttons for starting and stopping the engine;

The usual switches for lights, horn, windscreen wiper, etc.;

1 engine revolution counter;

2 vacuum gauges;

Indicator lights for oil pressure, engine-water temperature and the torque converter temperature.

All controls are duplicated at each end of the car, with the exception of the throttle and brake levers and the torque-converter change-over switch, which are removable. Additionally, the torque converter switch forms the master switch for the control column, without which the board becomes dead. It is also interconnected with other switches so that it is impossible to start the engine

Fig. 7. — Control column.

or operate the reverse gear unless the torque converter is in neutral.

The electrical equipment includes 24-volt batteries of 200 amp.-hr. capacity, which are mounted forward of the engine under the floor where they are accessible through a trap door. The 800-watt 24-volt dynamo is driven from the rear end of the torque converter by double V belts.

The body is tastefully decorated in the latest style adopted by the London Midland and Scottish Railway and is heated by thermostatically-controlled radiators from the engine water circulation. It is brillantly illuminated and is fitted with windows which give an entirely unrestricted view in all directions. As the engine is entirely under the floor, all of the car body is available for passenger seating.

As regards engine accessibility, it should be pointed out that as the engine is arranged under the floor in the centre of the car, top overhaul can be carried out from inside the car after removing a detachable floor trap, whilst refuelling; lubrication and the usual daily servicing can be completed without entering the car. Having placed the car over a pit, the engine and torque converter can be withdrawn as a unit. This arrangement of the power unit and reverse gear, it may be remarked, lends itself admirably for use in conventional bogie cars, an example of which has been running for over a year on the London Midland and Scottish (Northern Counties Committee) line in Northern Ireland. Further, owing to the simplicity of the control, very slight modification is necessary for multiple-unit train operation, in which each car carries its own power plant with all control from a single control station.

Principal dimensions :

Unladen weight of car	10 1/2 tons.
Fully laden weight of car	13.1 tons.
Wheelbase	21 ft. 0 in.
Overall length	41 ft. 1 in.
Driving wheel diameter	3 feet.
Driving axle ratio	4.016 to 1.
Engine power	130 H.P.
Power/weight ratio	10 H.P. per ton.
Maximum acceleration	3.25 ft. per sec.
Maximum speed	56 m.p.h.
Approximate consumption (1)	13 miles per gallon.

(1) Taken on a test run from Preston to Carlisle and back.

MISCELLANEOUS INFORMATION.

[621 .132.7 & 621 .43]

1. — 150-B. H. P. Diesel-geared shunting locomotive, London, Midland and Scottish Railway

(From *Diesel Railway Traction*, Supplement to *The Railway Gazette*).

Early this year the London Midland & Scottish Railway (L.M.S.R.) placed orders with various British firms for nine Diesel shunting locomotives of different types, and of this total the Hunslet Engine Co. Ltd. received the contract for four. It was agreed that the first unit should be the six-wheeled locomotive with a 150-B.H.P. M.A.N. engine which the Hunslet Company had constructed in 1932, and which had already been tried out on the L.M.S.R. system. This machine was taken out of service for a short period in order to make an inspection and paint it in standard L.M.S.R. livery, and some of the results of its service since that time were recorded in *Diesel Railway Traction* of November 3, 1933.

Delivery of the second locomotive has just been made, and it is intended to put it immediately to the duties performed by its forerunner, No. 7401, viz., 24-hour heavy shunting service for six days a week. Motive power is provided by an eight-cylinder McLaren-Benz oil engine which develops 150 B.H.P. at 1 000 r.p.m. It has been designed specially for locomotive service, and as the accompanying illustration shows, the bedplate casting is extended sideways and machined to fit between the frames, thus forming a very strong cross stay, and assisting in the perfect alignment of the crankshaft. To relieve the securing bolts of shear, a lip on the casting rests on top of the frame plate as in normal steam locomotive construction, and the centre portion of the casting forms the engine sump.

Fig. 1. — Latest L.M.S.R. Diesel shunting locomotive.

Two four-ram C.A.V.-Bosch pumps supply fuel to the engine cylinders, and the air is drawn through a Vokes filter. The cooling water and lubricating oil are circulated through a Reliance radiator mounted on the front end of the engine bonnet, behind which is a fan driven from the main engine. The radiator is built up in sections to facilitate any repairs

which may become necessary in the course of time, and a section can be changed in a few minutes. Starting of the engine is accomplished by means of a twin-cylinder Scott petrol engine, which is located in the bonnet although controlled from the cab. When the Diesel engine has reached a speed of about 200 r.p.m.

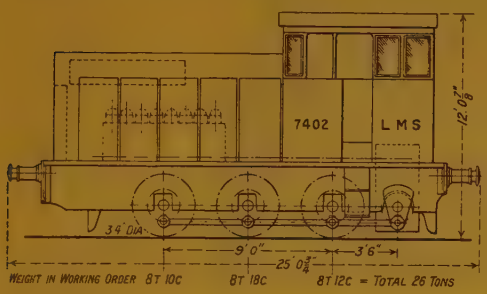


Fig. 2. — Diagram of 150-B.H.P. Diesel-geared locomotive.

the decompression valves are dropped and the engine fires immediately, the starting gear being automatically thrown out of action at the same moment.

A multi-plate friction clutch of the Hunslet patent type takes up the torque of the engine and passes it on to the transmission gear through a Hardy-Spicer coupling which effectively prevents cross strains being transmitted from the frames to the driving shafts, either through frame distortion on curves or imperfect alignment of the engine and gearbox. The efficacy of the Hunslet clutch and patent automatic pre-selective gear-changing mechanism in heavy service has been fully proved in the first L.M.S.R. shunting locomotive.

This pre-selective mechanism is complete in itself and is bolted to the gear-case adjacent to the control shafts which operate the gear-changing dog clutches by a twisting movement, and not by a push-and-pull action. The gears are moved into position by a pair of small hydraulic cylinders. The oil is passed through a selector valve controlled from the pre-selective lever in the cab, the oil being passed to whatever cylinder it is desired to operate. The pressure is supplied by a small intensifier operated by compressed air, the valve for which is coupled to the clutch pedal.

On the clutch being operated from the pedal, the first portion of the stroke disengages the main clutch, the valve having already been selected by a prior movement of the pre-selective lever. During the second half of the clutch pedal stroke the air valve to the intensifier is opened and the pressure immediately transferred to the oil, which passes through the selected valve and into the operating cylinder. The gear then goes over into position and the clutch pedal is released, but it is to be noted that the gears cannot be operated unless the clutch is first completely disengaged.

When engaged in any gear the mechanism in the gear-box is such that the valve automatically selects the requisite cylinder to bring the gear into the neutral position upon the next operation of the clutch pedal, irrespective of the position of the pre-selective gear lever. This ensures that the gear cannot be crashed straight across from one gear to another. The operation for changing gear is then as follows : The next gear is engaged on the pre-selective gear lever at the driver's leisure. Two separate depressions of the clutch pedal are made, the first one bringing the gear into neutral, the second engaging whichever gear has been selected. During the slight interval between these two operations, the throttle is either shut off when engaging a higher gear or opened up when engaging a lower gear. This operation is performed very quickly and the change of gear is effected in about three seconds. Due to the power being applied at the correct moment when the clutch is absolutely free, the engagement is perfectly silent, although no synchronising gear is fitted.

The control on the locomotive is quite simple, as the selector, throttle, and clutch pedal operations are automatically controlled by air, the driver being called upon to operate only one handwheel when making a gear change. All controls, whether for gear changing or driving, are duplicated, one set being situated at each side of the cab.

A simple air brake is fitted to the locomotive, an engine-driven compressor supplying air at 100 lb. per sq. inch pressure to four cylin-

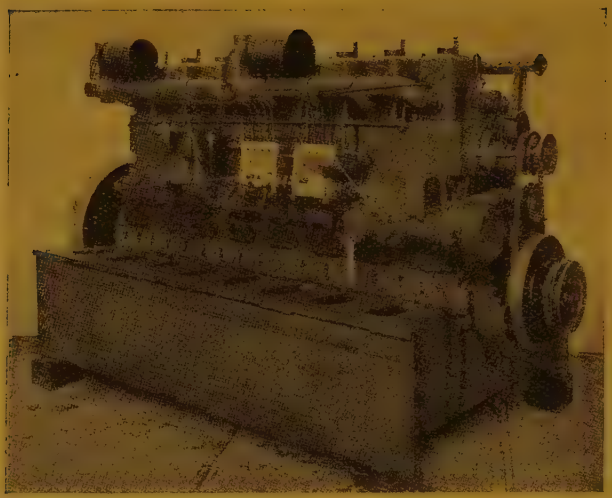


Fig. 3. — McLaren engine installed in L.M.S.R. shunting locomotive.

drical reservoirs. Arrangements have been made to totally enclose the cab if necessary, and heating pipes are provided for use in winter. The layout and principal dimensions of the locomotive may be obtained from the accompanying diagram, which also shows the method in which the drive from the gear-box is transmitted to the wheels. With a transmission efficiency of 85 %, the tractive effort on the lowest gear step, at a speed corresponding to 4.5 m.p.h., is 12 000 lb., giving an adhesive factor of 4.85 which, in conjunction with the sanding gear, is sufficient to ensure immunity from slipping. On test, a drawbar tractive effort of 14 500 lb. has been maintained without slipping.

[621. 138.3 (.42)

2. — Spray cleaning of locomotives on the London & North Eastern Railway.

(The Railway Gazette.)

The diagram reproduced below, for which we are indebted to the London and North Eastern Railway, shows the plant installed in the locomotive running shed at King's Cross, London, for cleaning locomotives by the spray or jet method. At present the installation is dealing with the wheels, motion and all parts below the footplate of 96 tank engines a week, the time allowance being three hours per engine per man, representing a saving of three hours on every engine treated. In addition, an incomparably better job is made of the work than can be effected by wiping with oil solvents, which themselves leave a residual film that acts as an adherent base for further accumulation. The effectiveness of the jet is also noticeable at the parts difficult of access by hand cleaning and it facilitates the mechanical examination of such parts besides improving the conditions under which repairs have to be carried out.

Prior to the installation of the present plant experiments were carried out with pumps operated on the rotary principle. These, however, were abandoned in favour of the plunger type of pump owing to the latter's larger

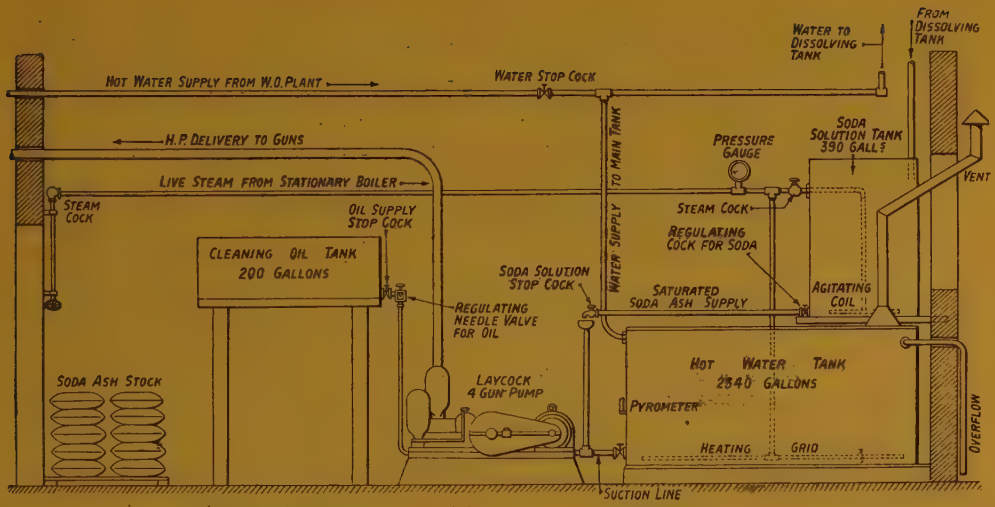


Fig. 1. — Diagram of King's Cross locomotive spray cleaning plant.

Fig. 2. — Service plant for locomotive spray cleaning equipment.

Fig. 3. — Cleaning jet in operation at King's Cross locomotive shed.

clearances and freedom from injurious effects caused by scale in the water. It is found that in the process of jet cleaning the maintenance of high pressures and temperatures is of considerable importance. The water supply of the King's Cross installation is obtained from a hot water locomotive boiler washing out plant and rarely falls below 120 deg. F., when entering the main water tank, and this is large enough to provide an ample reservoir in

order to permit of reheating. Reheating is effected by means of an H-shaped perforated grid on the bottom of the tank supplied with live steam from a stationery boiler and, in addition, a perforated steam pipe is fitted in the solution tank to heat the mixture and keep it agitated. All delivery pipe lines throughout the shed are effectively lagged and every endeavour is made to keep the temperature of the water in the neighbourhood of 200 deg. F., the operators being provided with leather gauntlets and protective clothing.

The chemicals employed.

The cleansing agents at present used at the King's Cross depot in combination with the water are soda ash and cleaning oil, though research is still being continued with a view to finding out the best medium for the purpose. It has been definitely proved that a jet of water, however, hot and at whatever velocity it may be projected is not in itself sufficiently effective. Owing to surface tensions some chemical medium is necessary to break the attachment of the oil film to the metal surface and this medium may take the form of emulsifying agents such as soaps, sulphonated oils, or alkaline substances like soda ash or silicate of soda.

The use of soda ash in the proportion (to the water) of about 0.3 % by weight has been found very satisfactory in removing grease, whilst being at the same time economical and giving the jet a cutting as well as a dissolving property. This medium, however, leaves a very flat and dry finish for which reason it cannot be used for parts above the footplate. If cleaning oil is added the finish is better, but the cost is correspondingly higher. The possibility of first cleaning the engine with an alkaline solution and then mist-spraying it with undiluted oil to obtain a desirable finish has yet to be tried. In operating the system, sufficient soda ash is dissolved in the mixing tank to suffice for one week's working, and this in then pumped by a semi-rotary hand pump into an elevated solution tank whence it feeds at a regulated rate into the suction line. This rate is adjusted by the setting of a tank cock, a second one being used to shut off the supply when the pump is not operating. The alternative or oil feed to the suction line is similarly controlled by the adjustment of a needle valve. In this way it is possible to obtain at the jets a cleaning solution containing two agents, those at present used being soda ash in the proportion of 0.3 % and Thelson oil 0.06 % by weight. This is forced by a four-gun Laycock electrically driven pump delivering three gallons per minute per gun at a pressure of 375 lb. per sq. inch through an overhead 1 ½-inch diameter hydraulic pipe line to the seven points with which the shed is equipped. From these, by means of 50-foot flexible hose pipes, all the engines on the six roads can be comfortably dealt with.

The effect on bearings.

The effect of spray cleaning on the bearings of the locomotives is being very carefully watched and at King's Cross shed the number so treated is graphed against the number of bearings overheated in order to examine the relationship between the two. From the data so far obtained, no increase has been revealed that can be attributed to this method of cleaning.

NEW BOOKS AND PUBLICATIONS.

[656. 25 (0, 656. 257 & 656. 258]

AMERICAN RAILWAY ASSOCIATION (A.R.A.), SIGNAL SECTION. — **American Railway Signaling Principles and Practices.** — 2 pamphlets (8 × 6 inches), illustrated. Chapter III : **Principles and Economic Phase of Signaling** (78 pages). — Chapter XIX : **Electric Interlocking** (94 pages). — Published by the Signal Section of the A.R.A., 30, Vesey Street, New York, N.Y. — Price : 35 cents (25 cents to members and railroad employees) each. — Price of the 18 chapters so far published : $ 5.75 and $ 3.95 respectively. Binder for 13 chapters : $ 1.

Chapter III first states the general principles of signalling : its purpose, the indications the signals give, the location of the signals, and gives in detail the conditions to be satisfied by the installations controlling the signals as well as the signalling equipment properly speaking.

The second part deals with a subject outside the ordinary scope of the other chapters with which we have dealt in the *Bulletin* on several occasions. Whilst the other pamphlets dealt with the design and description of the apparatus, the rules to be followed when erecting them and when they are in service, the present pamphlet puts before us in a condensed form the financial results given by modern signalling systems and suggests methods by which to calculate the probable savings which will be effected when projected schemes are put into service. The 29 numerical tables contained in it and the bibliographical notes on some 200 articles published in various special technical journals complete this brief summary.

Amongst the savings resulting from improved signalling, there is one which is rarely, because it is difficult to do so, given a monetary value, and this is the saving due to fewer accidents. Two railways have, however, supplied figures on the effect of the introduction of the automatic block system over a period of about 10 years.

Investigations of a financial nature have been made into such problems as signal cabins, interlocking plants, remote control, centralised traffic control, increase in the capacity of the lines, braking wagons in shunting yards, protection of level crossings, etc...

Chapter XIX describes the centralised interlocking systems operating the points and signals with electricity as the operating agency. Several designs of apparatus are dealt with, all of which are designed so that the position of the lever and of the points or of the signals controlled agree, and all of which are fitted with devices making impossible any unauthorised movement. The first condition is obtained by means of a control current which acts on a lock known as the *Indication Locking;* the second is guaranteed by the locking between the levers known as the *Cross Protection.* There is an important difference in the method of generating the control current and transmitting it. Two systems of doing this are at our disposal. In the first, the *Dynamic Induction System,* the power current is transmitted by the same wires as the control return current which is generated by the motor. In the other system the power current is transmitted to the different motors by a pair of feeders and an independent source of current is employed for the control. There is a relay controlling each apparatus in use, with which it forms an integral part, fed by two wires which start from the lever in the signal box. Two independent control wires connect the apparatus in the track to the lever.

This chapter also contains the description of an automatic signalling installation for a level crossing of two double-

track lines, and a detailed description of the appliances which by a single control, unlock electrically the points, move them and lock them in the thrown-over position (switch-and-lock movement).

E. M.

[656. 235 (.43)]

E. ADOLPH, D. LL., State Councillor and member on the Essen Area Management of the German State Railways. — **Eisenbahn-Gutertarifwesen (Railway goods rates).** — 1 vol. (8 1/2 × 6 inches) of 166 pages. — 1933, Verkehrswissenschaftliche Lehrmittelgesellschaft m. b. H. bei der Deutschen Reichsbahn, Berlin W. 8. (Price : 7.20 Reichsmark.)

This book, which deals solely with German rates, consists of two main parts, dealing with this question, the first from a legal aspect, and the second from a commercial point of view. ,

The author, in the first part, points out that railway legislation touches the public right in so far as it regulates the relationship with the authorities, and the right of the individual as concerns the dealings with the users. He gives particulars, which he analyses, of the legal prescriptions inserted in the commercial code, and in the ordinances dealing with railway traffic, and which have received legal sanction. The review also extends to international traffic. The regulations analysed deal with the essential points such as : the obligation of the carrier, the carriage contract and waybill, the route and length of carriage, the through rates, equality of treatment as between users of the railway, and the sanction and publication of rates. The author also examines the rates measures taken to favour export trade or to protect national industry and discusses them in relation to the commercial treaties, the financial agreements, and the customs arrangements. Finally he shows the general principles of the rates policy.

Rate making depends first of all upon the degree to which the management wish to cover the various expenditures by the receipts. The author examines the different theories which can be argued. He then sets out the actual features of the system of rates considered in relation to the element taken as the basis in the goods carried : the weight or volume, the value, and the combined system.

With regard to the standard rates, he has attempted to define the limits between which the rates can move. The method of fixing the rate in terms of the distance is one of the characteristic features of the rates structure : the zone rates system, first applied in Belgium on a large scale and which was in use in many countries before the War, was only introduced into Germany in 1920. The author gives particulars of the circumstances. Amongst other questions considered, we may mention privately owned wagons, special rates including competitive rates, and especially the K rates (rates for competing with road traffic), and then the international rates, the clauses of which are analysed, both those affecting the consignors and those which fall within the domestic organisation of the railway (for example the sharing of the receipts).

E. M.

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Deutsche Gesamtausgabe der Dezimalklassification (Complete German edition of the decimal classification). — Published by the German Standardisation Committee. — Beuth-Verlag, Dresdener Strasse, 97, Berlin.

The German Standardisation Committee has announced the issue in the near future of a complete edition of the decimal classification, revised and completed in accordance with the most recent international conventions.

The work is to include an introduction giving the principles of the decimal classification and indications as to using it. The systematical part will include some 70 000 articles, and the alphabetical index the same number of words.

Owing to the size of the work, it will be published in ten numbers, each of 160 pages, and will appear quarterly; the issue will be completed in 1936.

A. C.

[62. (01 & 625. 143]

ASSOCIATION SUISSE POUR L'ESSAI DES MATERIAUX (A. S. E. M.) (*Swiss Association for Testing Materials*). — **Second International Day on Rails** (Zurich, 15 and 16 June 1932). — Report No. 16 of the Swiss Association for Testing Materials. — Report No. 43 of the Federal Materials Testing Laboratory. — One volume, 29.5 × 21 cm. (11 1/2 × 8 1/4 inches), of 408 pages fully illustrated with drawings and photographs. — March 1933, Zurich, Association Suisse pour l'Essai des Matériaux, 27, Leonhardstrasse (Price : 25 Swiss francs).

The Swiss Association for Testing Materials organised an international day's meeting devoted to rails « in order to facilitate the exchange of theoretical ideas and practical results relating to rails, as these questions are much to the fore in all countries and have not only great scientific interest but great practical importance ».

The first International Day devoted to the study of questions relating to rails was held in Zurich in 1929. The second day also was held in Zurich, in June 1932.

The 34 reports presented can be classified under the following heads :

I. General.
II. Wear.
III. Brittleness. — Internal stresses.
IV. Operating results.
V. Welding.

Questions relating to the track were only touched upon so far as they had a real bearing on questions I to V.

The principal reports presented during the Second Day have been collected into a volume published on behalf of the Swiss Association for Testing Materials.

If is impossible to give, in a limited space, a detailed analysis of all the reports presented. It should be noted, however, that they are all interesting and that the volume as a whole forms a document of the greatest value for investigating the conditions under which rails are tested, the defects of rails, and the way they stand up in service.

In order that no report of any interest be omitted the following is a complete list of all reports read :

R. Kühnel. — Work of the German Commission on testing rails.

P. Forcella. — The methods used for testing rails in the Metallurgical laboratory of the Royal Experimental Institute of Communications, at Rome.

W. Titze. — Siemens Martin basic steel rails considered from the points of view of technological tests for strength and metallurgical tests.

M. Ros and A. Eichinger. — Methods of carrying out laboratory, works, and service tests of rails.

C. de Benedetti. — Methods of testing rails at the works and in service.

A. Plana Sancho. — Particulars of tests and of wear of rails on the Spanish railways.

H. Araki & S. Saïto. — The reciprocal wear of rails and tyres.

C. de Benedetti. — Protection of rails against wear and rust. — Rail breakages.

M. Spindel. — Internal stresses in, and resistance to wear, of rails.

M. Suzuki. — Investigations into the wear of carbon steel rails.

P. Forcella. — The type of fracture of rails in service related to the elasticity tests and those under repeated blows with alternating bending.

F. Regler & A. Pohl. — Internal stresses in rails and their investigation by means of X-rays.

S. Ikeda. — Internal fissures in rails.

S. Ikeda. — A quick method of determining the limit of tensile strength by measuring the electrical resistances of annealed or heat-treated steels.

G. Grenier. — The manufacture of martensitic steel rails at the Neuves-Maisons steel works.

Ch. Libotte. — Method of hardening the rolling surface of rails.

R. Walzel. — Results in service and results of new tests of rails of manganese steel made in the electric furnace.

Herwig. — Results in service with rails which have undergone a beginning of wear.

C. Lucchini. — Information collected upon rails in service.

Hungarian State Railways. — Information on the behaviour of old rails in service.

A. Blaser. — Rail wear and creep.

M. Ros and A. Eichinger. — Welding rails.

K. Jurczyk. — Electric welding of rails.

K. Jurczyk. — Endurance tests of welded rails.

J. Nemcsek. — Influence of the structure of the track on the conditions rails have to satisfy.

D. Székely. — Arrangements for allowing the expansion of long rails on the Budapest tramway lines.

A. Hellermann. — New points of view from which to improve the railway track.

H. Shibata. — Measurement of the stresses and deformations of the rail by the electric telemeter.

M. Suzuki & H. Chiba. — The defectoscope : a coach for the electromagnetic inspection of the track.

J. B. Farwell. — The Sperry detector cars.

N. Stchapoff, P. Sakkarow, O. Uskowa and N. Gherlivanow. — Russian notes.

These reports, written in French, English and German, are preceded by an introduction in these three languages, which gives the reader a general review of the subject dealt with.

They are well illustrated by figures, photographic reproductions and diagrams, which greatly add to the value of the publication.

The reader will be able to appreciate from the list of subjects dealt with, the great wealth of information contained in the 400 pages of the volume. The specialists in these questions cannot be too strongly recommended to read this work as they will all find in it ideas deserving of consideration as well as a very valuable documentation.

The writer of this note finds it difficult to draw the particular attention of the reader to any given report. The reader, however, will be able to find what he is looking for quite easily in the volume.

We would like, before ending this note, to call particular attention to the report by Messrs. Ros and Eichinger, which gives a very valuable review of the whole question of rail testing.

The paper presented by Messrs. Regler and Pohl on the application of Röntgen rays to the investigation of the internal stresses in rails also deserves to be specially mentioned. It contains remarks of great interest on the influence of the deformations and of the alterations in the atomic structure on the elastic properties of the metals.

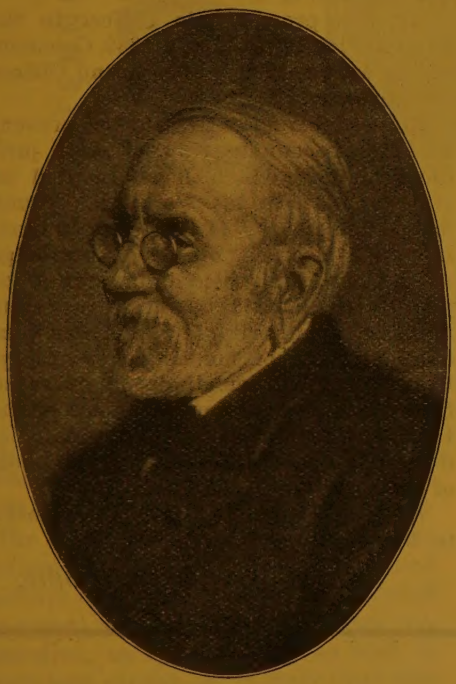
The 3rd Rail Congress will be held in Budapest in the 1934 autumn.

R. D.

OBITUARY.

Mr. Gaston GRIOLET,

Former Deputy Chairman of the Board of the French Nord Railway Company,
Founder Member of the International Railway Congress Association,
Former Member of the Permanent Commission of this Association.



Mr. Gaston GRIOLET, one of the founders of the International Railway Congress Association, in 1885, and a member of the Permanent Commission of the Association until 1926, that is to say for 40 years, died in Paris on the 24th January, 1934.

Born on the 6th February 1842, Mr. GRIOLET, after completing his scholastic education, became a barrister and was one of the Secretaries of the Advocates Conference, who are always selected from the most distinguished of the Juniors.

He was appointed as Counsel to the Commission appointed to replace provisionally the State Council suppressed on the fall of the Empire, on the 4th September 1870. When the State Council was reorganised by the law of the 24th May 1872, he was nominated Master of the Court of Appeals. He was attached to the Public Works Section and was lecturer in Law at the Ecole des Ponts et Chaussées. He was decorated with the Légion d'Honneur as long ago as 1875, at an age when this decoration was still very rarely given.

He resigned his public positions in 1875 to join the Board of the French Nord Railway Company and its Managerial Committee, on which he replaced Mr. Léon SAY on the latter's appointment to the Ministry of Finance. As is generally known, the Nord Railway, unlike the other great French Companies, has *no General Manager* over all departments; there is an *Operating Manager*, but neither the Chief Mechanical Engineer nor the Chief Permanent Way Engineer come under him. The Managing Committee composed of Directors, including the President and the Vice-Presidents of the Board, forms the real link between the three main departments and has a much more active function to carry out than the same Board of the other great Companies. Mr. Griolet held an important position on it for forty years.

When he joined it, the Nord was being completely reorganised on account of the new contracts concluded by it with the State for the extension of its concessions which included amongst others the

construction of the Grande Ceinture and the taking over of the lines built by the well known speculator Philippart (Lille to Valenciennes and North-East). Mr. Griolet played a great part in working up these important matters. He also was closely concerned in drawing up the agreements of 1879 (resumption of the Picardy-Flanders concessions), then that of 1883, which completely modified the system of working of all the great Companies by incorporating in them most of the lines built under the vast programme of public works voted by the Chamber of Deputies on the initiative of Mr. de Freycinet, who became Minister of Public Works on the fall of the Ministry formed by the Duc de Broglie, on the 16th May 1878.

Mr. Griolet, in 1887, was appointed Vice-President of the Board of Directors of the Nord, which duties he carried out until the 15th January 1932, when he was made an honorary Vice-President.

Independently of his duties on the Nord, Mr. Griolet showed great activity in all arrangements which grouped the great French companies together. We have mentioned the active part he took in founding the International Railway Congress Association : he attended the 6 Congresses between 1885 and 1900 and some of the subsequent ones.

He sat on many boards of railway companies in Spain and North Africa, and of other undertakings, such as electrical (Compagnie Parisienne de Distribution d'Electricité, Nord-Lumière, Triphasé, Eclairage et Force par l'Electricité, Energie Electrique du Maroc), and other industrial, commercial and colonial undertakings. He was for a long time president of the Board of the Banque de Paris et des Pays-Bas.

He was promoted to Officer in the Légion d'Honneur in July 1889, Commander in August 1900, and to Grand Officer in February 1924.

His business activities did not prevent him from occupying himself with juridical matters which had occupied so great a place in his work as a young man, such as the Dalloz compendium. His great learning, his deep knowledge of the law, and the administration of public and private business, gave him undisputed authority, to which was joined the charm of unchanging courtesy. His memory will remain deeply engraved in the minds of all those members of the International Railway Congress Association who had the pleasure and honour of working with him.

We offer our respectful condolences to his family.

The Executive Committee.